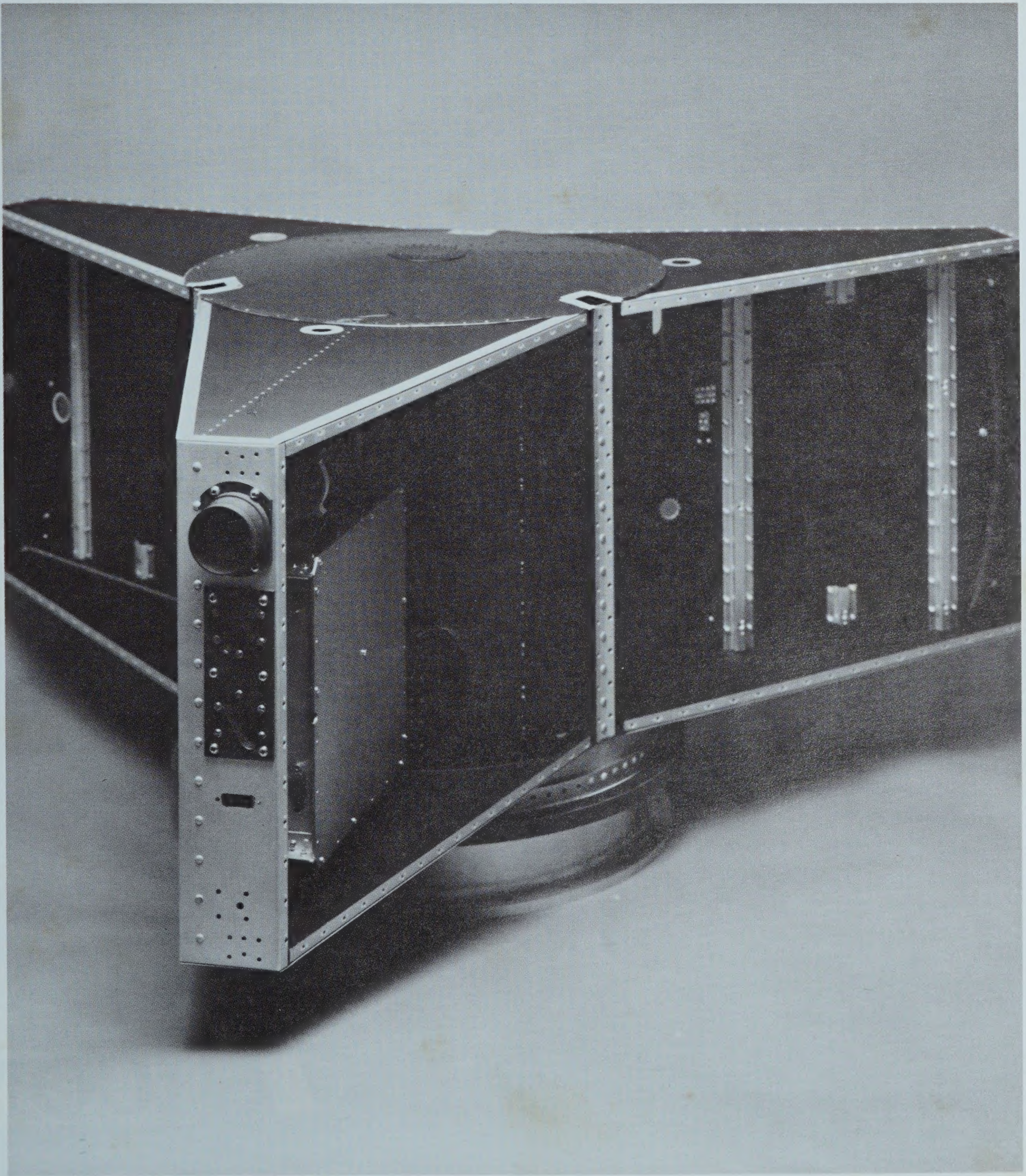
AMSAT

SATELLITE JOURNAL

Journal of the Radio Amateur Space Program

January-February 1986, No. 7



Published by AMSAT®—The Radio Amateur Satellite Corporation

ICOM 440MHz

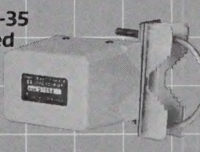
For a Total UHF System, Choose ICOM

ICOM offers a variety of UHF gear to meet your operating requirements... the IC-471H base station transceiver, IC-47A compact mobile, IC-04AT or IC-4AT handheld transceivers, and the RP-3010 crystal controlled repeater.

The IC-471H all mode 430–450MHz base station transceiver provides 10 to 75 watts of adjustable power. With 32 full-function memories, 32 PL tones, memory scan, mode scan and programmable band scan, the IC-471H provides maximum UHF base station performance. The IC-471A 25 watt version is also available.

The IC-47A 25 watt 440–449.995MHz ultra-compact FM mobile provides superb performance in the mobile environment. Measuring only 5½" wide by 1½" high by 9" deep, the IC-47A also features nine full-function memories, 32 built-in PL tones and a complete scanning system. Each unit comes standard with an HM-23 mic with up/down scan and a mobile mounting bracket.

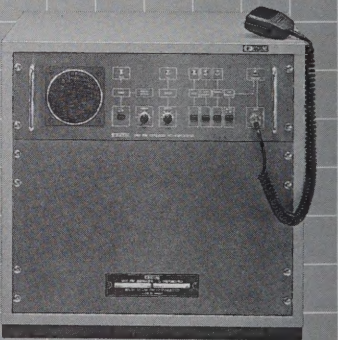
Optional AG-35 Mast Mounted GaAsFET Preamplifier for IC-471H



The IC-04AT top-of-the-line UHF handheld features DTMF direct keyboard entry, LCD readout, 32 PL tones, 3 watts standard (5 watts optional) and 10 memories which store duplex offset and PL tone.

The IC-4AT handheld features 440–449.995MHz coverage, a DTMF pad, 1.5 watts output and thumbwheel frequency selection.

The IC-04AT and IC-4AT come standard with an IC-BP3 NiCd battery pack, flexible antenna, AC wall charger, belt clip, wrist strap and ear plug. PLUS a wide variety of slide-on battery packs and accessories are available.



The RP-3010 crystal controlled UHF repeater covers from 430–450MHz and includes CTCSS, 3 digit DTMF decoder and CW ID'er.

See ICOM's full line of UHF gear at your local ICOM dealer.

ICOM

First in Communications

ICOM America, Inc., 2380–116th Ave NE, Bellevue, WA 98005 / 3331 Towerwood Drive, Suite 307, Dallas, TX 75234

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions. 471H1184

AMSAT

SATELLITE JOURNAL

Journal of the Radio Amateur Space Program

January-February 1986, No. 7

Editorial Address: P.O. Box 575, Wharton, NJ 07885

Publisher

Doug Bornstein, WA2JTC

Headquarters Staff

Director of Administration: Martha Saragovitz

Advertising Office: c/o Douglas Communications, 18653 Ventura Blvd., Suite 550, Tarzana, CA 91356 Phone: 818-609-1944

AMSAT: 850 Sligo Ave., Suite 601, Silver Spring, MD 20910 Phone: 301-589-6062 Telex: 892320-AMSAT

AMSAT SATELLITE JOURNAL (USPS 041-850) is published monthly except February, June, August, October for $16 (inseparable from membership dues of $24) by AMSAT 850 Sligo Ave., Suite 601, Silver Spring, MD 20910. Second-Class Postage Paid At Silver Spring, MD 20910 and at Additional Mailing Office. POSTMASTER: Send address changes to AMSAT SATELLITE JOURNAL, 850 Sligo Ave., Suite 601, Silver Spring, MD 20910.

ISSN 8756-2480

January-February 1986
Volume 1 Number 7

CONTENTS

On the cover: Scheduled for a late summer or early fall launch, AMSAT's Phase IIIC spacecraft undergoes development at laboratories in Golden, Colorado. Photographed in November 1985, the satellite, with its panels removed, awaits transponder and control modules.

PERSPECTIVE

Traditionally the new year requires fresh thoughts and new ideas, as well as revised plans for correcting the ills of the past and moving ahead boldly into the, as yet, uncertain future. True to that spirit, let's take a look at what lies ahead for AMSAT and the amateur satellite community and some of the options for guiding and directing the prospects for our organization.

Every journey into the future starts from the present and the the traveler is well disposed to begin with a look-see at his surroundings to best understand how to proceed. Thus the beginning of 1986 sees three active OSCAR-series satellites in orbit, all quite healthy. AMSAT-OSCAR-10, now a veteran of two and one half years, continues to provide reliable communications and give testimony to the soundness of its design. Indeed a recent failure in a section of memory (likely the result of a stray atomic particle bounding through the spacecraft) has not stilled the satellite. Designers had forecast such a happenstance and made provisions to bypass its damaging effects.

The UoSAT birds continue on their missions, providing researchers at the University of Surrey with scientific data from a variety of experiments. Of growing interest to many hams is the digital communications experiment, or DCE, on board UoSAT-OSCAR-11. That package has been a flying testbed for packet radio store-and-forward techniques and will soon become available, in a limited fashion, to packeteers around the world. (See a discussion of the latest DCE news in The Digital Front in this issue.)

Fewer in numbers, although no less enthusiastic, are the home researchers. Armed with data decoding programs, such as that recently released through AMSAT's Software Exchange by Bob Diersing, N5AHD, these amateur scientists have been getting first-hand experience with real and very useful satellite telemetry from the UoSAT scientific satellites.

Another enthusiastic subculture within the satellite community are the users of low-earth-orbiting satellites, such as the remaining Russian satellites. Those birds, part of a flotilla of spacecraft unhatched several years ago in a large-scale launch, continue to serve the Mode A fan. The 10-meter-to-2-meter transponders not only fill the need for simple, easy-to-access satellite communications, but also serve to remind us of the impressive design and launch capabilities of our Russian friends. Unfortunately, one long-time member of the Russian fleet expired towards the end of 1985—RS-8.

That's what's up. What's still on the ground? As most readers know, the Phase IIIC spacecraft is taking shape at AMSAT laboratories in Golden, Colorado. The frame is being prepared and fitted with transponder modules prior to its trip to West Germany and the University of Marburg where it will be primed for launch later in 1986. The new bird will follow its predecessor, OSCAR-10, into a high-flying Molniya orbit, providing extended communications range to much of the world for many hours at a time.

Not as fortunate is France's Arsene satellite project, which ran into difficulties during 1985 and has apparently slipped off the Ariane launch it was to have shared with Phase IIIC. Arsene, also a high elliptical-orbit bird, will be rescheduled to an as yet unspecified launch—delayed but not lost.

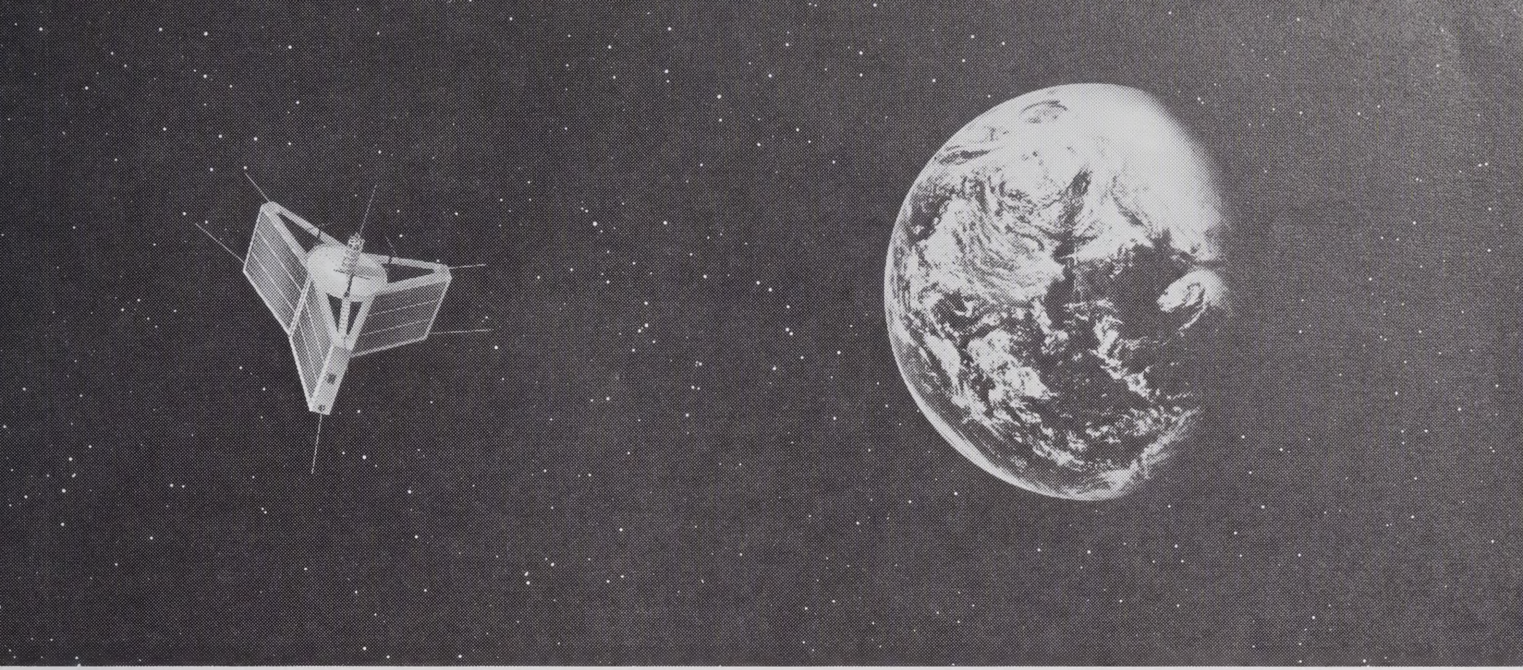
Not so indefinite is the launch of the Russian team of RS-9 and RS-10. Launch of those satellites is reported for February and indications are that they will follow the low-orbit path of their predecessors. A unique feature of the new satellites is Mode K, a communications facility that will make use of a 15-meter uplink.

Also sitting on the ground but ready for launch is JAS-1. A product of Japan's JAMSAT and the JARL organizations, the small spacecraft will take to space sometime around August of 1986 aboard a Japanese launch vehicle. Anticipating the growth of packet radio, Japanese designers included a store-and-forward facility on the spacecraft as well as a conventional Mode J transponder—uplink on 145 MHz and downlink on 435 MHz.

It's time to move slightly into the future with a look at the drawing boards of the satellite designers. Within AMSAT eyes are cast upon two proposals advanced and advocated at the recent AMSAT general meeting in Colorado. One favored by Dr. Karl Meinzer, DJ4ZC, of AMSAT DL is an extension of the current Phase III series—a Molniya satellite with a high-power twist. Karl sees a spacecraft with high-power transponders that will extend communications capability to less powerful ground stations. He suggests that such a bird would even be routinely accessible from mobile installations.

A different plan for the drawing board is advanced by AMSAT's Jan King, vice president for engineering. Phase IV looks good to Jan, some configuration of geosynchronous satellites providing reliable 24-hour service from most locations on the Earth. Late in 1985

(Continued on page 6)



The DX is better out here. Ask anyone who owns an FT-726R.

It's true. Linking up to OSCAR 10 is the one sure way to bring the world into your ham shack. No matter where your shack is.

FT-726R owners know. You'll find them working the world from their apartments. Attics. And from their antenna-restricted neighborhoods.

They'll even boast of a signal quality and DX potential that would make any 20-meter operator envious. Regardless of where we are in the sunspot cycle.

In fact, the FT-726R is the world's most popular link to OSCAR 10.

And for good reason. This 2-meter, 10-watt rig gives you full cross-band duplex capability. Simply plug in two optional modules, one for 435-MHz operation, another for cross-band duplex.

You can set up your earth station just about anywhere. All you need is the 726 and two Yagi antennas: 435-MHz for transmit and 2-meters for receive.

Even as a conventional base station, the FT-726R is a real standout.

You can choose from three operating modes: SSB, FM or CW. Expand to three-band operation with your choice of optional modules for 10 meters, 6 meters, 430-440 MHz and 440-450 MHz.

Then store your preferred frequencies and modes into the eleven memories for instant recall. With pushbutton transfer capability to either of two VFO registers. And versatile scanning functions you'd expect from a Yaesu radio.

Plus you get a lot more extras, including a built-in speech processor, all-mode squelch and a noise blanker.

So no matter where your shack is, let Yaesu's FT-726R introduce you to OSCAR 10. The world is waiting.

YAESU

Yaesu Electronics Corporation
6851 Walthall Way, Paramount, CA 90723
(213) 633-4007

Yaesu Cincinnati Service Center
9070 Gold Park Drive, Hamilton, OH 45011
(513) 874-3100

Prices and specifications subject to change without notice.

(Continued from page 4)
study teams were organized to take a look at both the extended Phase III and new Phase IV ideas.

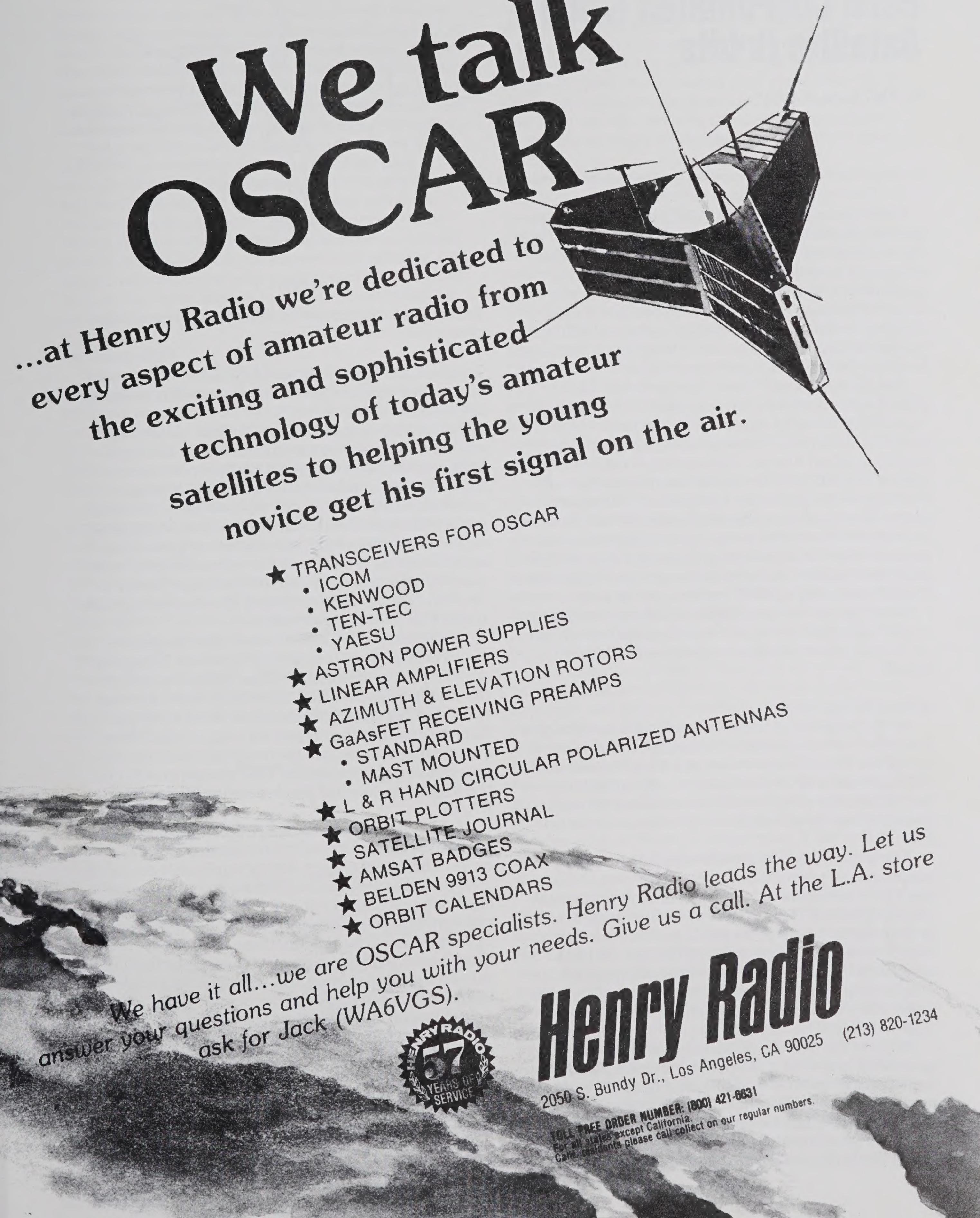
The satellite team at the University of Surrey made news in 1985 with announcement of one and possibly two more birds in the UoSAT flock. UoSAT 3, according to Dr. Martin N. Sweeting, G3YJO, will include a store-and-forward electronic mail system as well as an imaging device that will send low-resolution pictures of the ground to amateur stations. Work has reportedly begun on the UoSAT-3 satellite with an anticipated launch sometime between the mid 1986 and mid 1987.

That's a brief synopsis of what has been, what is, and what will be, at least as far as hardware is concerned. What about the AMSAT organizations? The trend over the last several years is clearly towards a strengthening of the various affiliated AMSATs around the world. As interest in satellites grows..indeed as such communications becomes a staple of every amateur's shack..membership in AMSAT will, we hope, increase. Many new satellite communicators will opt to join a national society, rather than the founding AMSAT organization, to obtain information and help more closely tailored to his or her needs.

Along with growing membership, the regional AMSAT groups will develop facilities for designing, constructing, and securing launches for their own satellites. In the West, the construction centers in West Germany, England, and Japan clearly point to a very diversified approach towards satellite construction and development of a very large body of skilled satellite builders.

There will be a decidedly different climate in the amateur satellite world several years from now with not one but many AMSATs, hopefully joined in global confederation that will coordinate and prevent duplication of efforts. These are indeed exciting times. Consider yourself a front-row observer to some dramatic developments in the next several years.

Harold Winard, KB2M


We talk OSCAR
...at Henry Radio we're dedicated to every aspect of amateur radio from the exciting and sophisticated technology of today's amateur satellites to helping the young novice get his first signal on the air.
★ TRANSCEIVERS FOR OSCAR
• ICOM
• KENWOOD
• TEN-TEC
• YAESU
★ ASTRON POWER SUPPLIES
★ LINEAR AMPLIFIERS
★ AZIMUTH & ELEVATION ROTORS
★ GaAsFET RECEIVING PREAMPS
• STANDARD
• MAST MOUNTED
★ L & R HAND CIRCULAR POLARIZED ANTENNAS
★ ORBIT PLOTTERS
★ SATELLITE JOURNAL
★ AMSAT BADGES
★ BELDEN 9913 COAX
★ ORBIT CALENDARS
We have it all...we are OSCAR specialists. Henry Radio leads the way. Let us answer your questions and help you with your needs. Give us a call. At the L.A. store ask for Jack (WA6VGS).
HENRY RADIO 57 YEARS OF SERVICE
Henry Radio
2050 S. Bundy Dr., Los Angeles, CA 90025
(213) 820-1234
TOLL FREE ORDER NUMBER: (800) 421-6631
For all states except California.
Calif. residents please call collect on our regular numbers.

Bahn Coordinates Guide Satellite Orbits

by Phil Karn, KA9Q*

Users of the AMSAT-OSCAR-10 satellite have frequently heard the expression "bahn coordinates," but what exactly are bahn coordinates and why are they important to satellite users? An equally important question is why those numbers seem to change so often? The answers to those questions reveal a fascinating method for determining where a satellite is in space and how it will perform, both for the user and for ground-based spacecraft controllers.

The German word "bahn" means "path," especially one taken by a moving object. For example, "autobahn" literally translates to "car path" (highway) and "eisenbahn" means "iron path" (railroad tracks). Applied to space, bahn refers to the orbital path of a satellite. Since the laws of physics dictate that a satellite orbit must be contained within a plane, bahn coordinates are therefore orbital-plane coordinates. Since this is one of those rather rare occasions where a German word is shorter than its English counterpart, the term has caught on within the English-speaking AMSAT community as well.

Now that we've succeeded in speaking something closer to English, we're left another question—What are orbital-plane coordinates, anyway?" Glad you asked.

A bit of background

An explanation of orbital-plane coordinates begins best with a review of some fundamental characteristics of the Phase III spacecraft. In fact, a discussion of the orientation of OSCAR-10 in its orbital plane is very important since it determines where the satellite antennas are aimed at any given point in the orbit.

As everyone knows, a satellite spins like a gyroscope; once set in motion either device obeys Newton's laws and remains in motion until acted upon by an outside force. (An example of such an outside force is the magnetic field of the earth, which reacts with electric magnetorquers on board OSCAR-10.) If the satellite antennas point at the earth when the spacecraft is at apogee, they point precisely away from the earth when the satellite is at perigee, that is, on the opposite side of its orbit.

Because the OSCAR-10 antennas point along the spacecraft spin axis, it is impossible to keep them continuously pointed at the earth (Fig. 1). To do that, spin stabilization must be scrapped in favor of a three-axis stabilization approach. Alternatively, the antennas must be mechanically or electrically "despun" while the rest of the spacecraft spins. Either

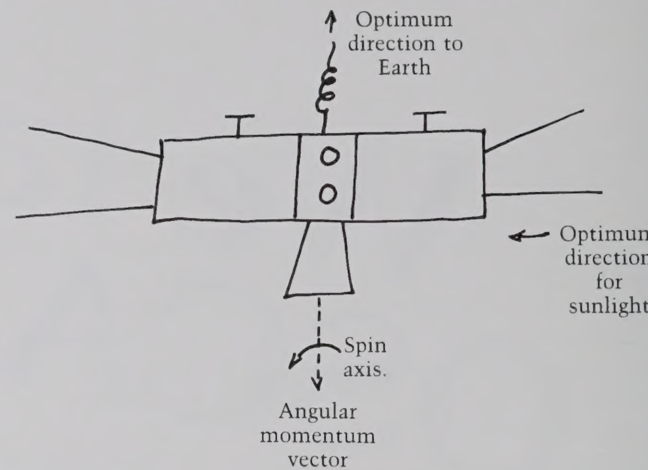


Figure 1

Because OSCAR-10 is spin stabilized, its antennas do not always point towards the Earth.

approach can be difficult and expensive, but are necessary for a Phase IV geostationary satellite designed for continuous service.

But unlike a geostationary satellite, the antennas on OSCAR-10 cannot continuously face the earth. However, the time during which they point away from the earth has been minimized by the spacecraft's elliptical orbit and by orientation of the antennas so that they face the earth at apogee. To figure out where the antennas are pointing at any given time, and to determine just how close the satellite is to its nominal operating attitude, it became necessary to develop a means of representing the orientation with respect to the spacecraft's orbit.

Most users of OSCAR-10 know that the spacecraft's orbital plane is at an angle of about 26 degrees with respect to the equator. That angle, also called the satellite's inclination, stays fairly constant over time. The tug of the sun and moon do cause small fluctuations, but they're not very significant. However it takes not one, but two numbers to fix the orientation of a plane in space. That second number is the Right Ascension of the Ascending Node, or RAAN.

Unlike inclination, the RAAN changes continuously with time as a result of the earth's equatorial bulge. The rate of change depends primarily on the orbital period as well as the inclination; only at an inclination of 90 degrees does RAAN stand still. The sun-synchronous orbits used for OSCARs 6 through 9 plus OSCAR 11 had inclinations and periods that caused the RAAN change rate to cancel the motion of the earth around the sun, but we're getting a little off the bahn...I mean track.

Inclination and RAAN are two of the references needed to set up a three-dimensional coordinate system based on the orbital plane. The third reference is the position of apogee and perigee within the plane. To develop this reference, an imaginary straight line can be drawn to connect those two points. The line, which would pass through the center of the earth, is called the "line of apsides." The orientation of that line with respect to the earth's equator is the orbital

element, or parameter, known as the "argument of perigee."

As frequent OSCAR-10 users have learned, the argument of perigee changes constantly with time. A singular exception is an inclination of 63.5 degrees, at which the argument of perigee remains fixed. Note that this is different than the inclination required to maintain a constant RAAN. Thus it is impossible to have an elliptical orbit about the earth for which both RAAN and the argument of perigee remain constant.

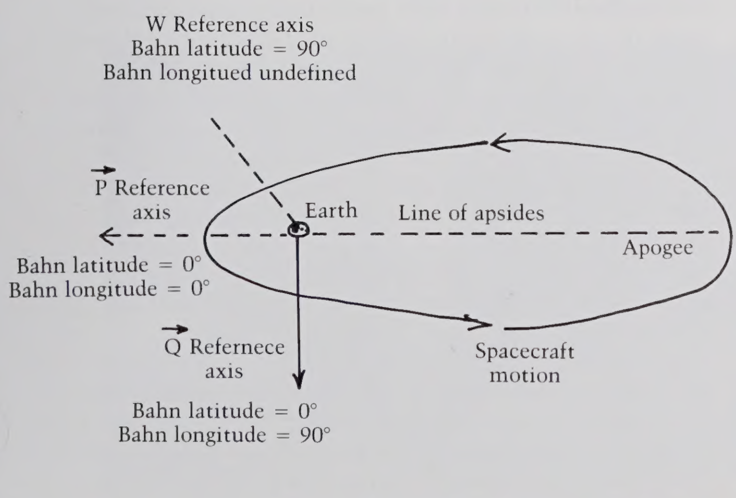
The key point to remember from the above is that, in general, an orbital plane is not fixed in space. It would be fixed if the earth were perfectly spherical, and the much smaller effects of the moon and sun could be ignored. However, the earth is not a perfect sphere and real orbits have planes that twist and turn at slow but easily predictable rates. Accordingly, any measurements taken with respect to an orbital plane, such as the orientation of a satellite, must therefore include the time at which they were made.

Spinning right

It is true that OSCAR-10 is a pretty good gyroscope; once it is spun and pointed at a given star it will continue spinning and pointing at that same star for a remarkably long time. But even if it were perfect, its orientation with respect to its orbital plane would change because, in proper terms, orbital plane coordinates do not establish an inertial frame of reference.

Given inclination, RAAN, and the argument of perigee, it is possible to establish both the orientation of the orbital plane in space and the proper "rotation" of the orbital ellipse within it. (The other three Keplerian elements—mean motion, eccentricity, and mean anomaly—don't have much significance in a discussion of bahn coordinates with the small exception that the argument of perigee becomes meaningless when the eccentricity equals zero.) Given the orientation of the orbital ellipse in space, we can now set up our bahn or orbital-plane coordinate system and determine the orientation of the spacecraft spin axis within it.

Figure 2



An orbital coordinate system uses three reference axes, here labeled P, W, and Q. The orbit plane is in the plane of the page. The W reference axis is perpendicular to the page.

Three dimensional coordinates can be expressed either in spherical (latitude and longitude) or Cartesian (rectangular) form. Although the spherical form is more commonly mentioned, it is easier to start with the Cartesian form. A three-dimensional Cartesian coordinate system requires three mutually perpendicular reference axes; for the orbit plane the letters P, Q, and W are used to label these axes (Fig. 2). (To avoid confusion the more common letters X, Y, and Z are not used because in astrodynamics they refer to a coordinate system based on the earth's spin axis.)

Since the originating point of our coordinate system is the center of the earth, all three reference axes point out from there. The P axis points to the perigee point of the satellite while the Q axis points at a spot along the orbit where the satellite will be after it has moved 90 degrees past perigee as seen from the center of the earth. The P and Q axes therefore lie in and define the orbital plane, while the W axis, also known as the "orbit normal," is perpendicular to the first two axes (and the orbit plane) and completes a so-called right-handed set. If the satellite is in a prograde orbit, one with an inclination below 90 degrees, the W axis points "up" into the north celestial hemisphere. If the satellite is retrograde, that is, with an inclination above 90 degrees, the W axis points "down" into the southern sky.

While Cartesian coordinates are easy to work with mathematically, most people are more familiar with spherical (latitude and longitude) coordinates. To promote a better understanding of an orbital-plane coordinate system it can be first expressed in terms of latitude and longitude and then transformed into values for the Cartesian system. Thus, a direction of 0 degrees latitude and 0 degrees longitude corresponds to the P reference vector, which points from the center of the earth through the perigee point.

If antennas are pointed along that direction, they will face precisely away from the center of the earth at perigee and precisely towards the center of the earth at apogee. Such a condition is the ideal orientation for a Phase III spacecraft (Fig. 3). If we keep latitude equal to zero but increase longitude, we begin to sweep out the orbit plane in the direction the satellite moves within it. If latitude is made positive. the antennas would be tilted above the orbital plane (i.e., in the direction of the W reference axis). If the latitude is made negative, the antennas would be tilted below the orbital plane.

It seems that a number has been lost somewhere. Only two numbers are needed to describe a latitude-longitude direction in space, but three are needed for the Cartesian coordinate system. What happened to the third number? Nothing really. It merely represents the magnitude of the vector or pointing direction. On OSCAR-10, that quantity has a very elegant and powerful meaning—it is the spin rate of the satellite! In other words, if the spin rate is varied without changing its direction, the bahn latitude and longitude remain unchanged while the magnitude of the pointing vector changes.

In physical terms, the three-dimensional bahn coordinates represent the angular momentum vector of the spacecraft. An onboard computer carries software

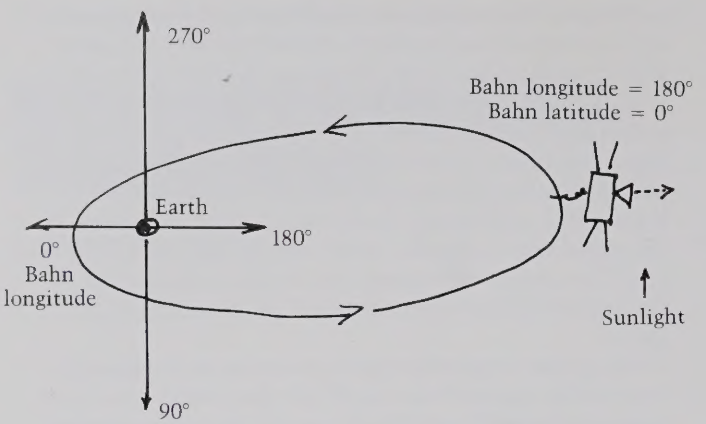


Figure 3

The best user coverage for a Phase III-type spacecraft has the antennas pointed toward the Earth at satellite apogee.

that will change this vector on command. This surely has to be one of the most remarkable achievements in the entire Phase III command system. A control operator can simply uplink two numbers informing the spacecraft where its angular momentum vector currently points. The spacecraft can determine its magnitude, i.e. the spin rate, by itself. Three more numbers follow giving the desired new angular momentum vector, in other words, the new bahn latitude and longitude as well as the spin rate. During the next passage through perigee, at the point where earth's magnetic field is strongest, the onboard computer automatically pulses the magnetorquers, reorienting the spacecraft to the new position. One or two orbits later, the control operator can check in again to determine the progress of the maneuver, but the maneuver itself is carried out automatically!

Collision consequence

A complicating factor resulting from an accident two years ago causes an important complication here. The values of 0 degrees latitude and 0 degrees longitude are not used with reference to OSCAR-10. A more likely combination is 0 degrees latitude and 180 degrees longitude. The reason for this difference relates to the collision between the Ariane launcher and the new OSCAR-10 spacecraft shortly after deployment in June 1983.

When control was regained over the satellite and its orientation was determined, it was discovered that the satellite was turning slowly in the opposite direction from that intended. Since it was both risky and unnecessary to cancel out this reverse rotation, the satellite was instead spun up in the backward direction. Reverse rotation corresponds to reversing the direction of the angular momentum vector, but since the software doesn't like the idea of a negative spin rate, it was easier simply to invert the coordinate system. Therefore a set of bahn coordinates for OSCAR-10 describe where the kick motor, and not the antennas, point. For example, a bahn latitude of -10 degrees and a bahn longitude of 170 degrees indicates that at perigee the kick motor points at a spot on the earth slightly south and east of the subsatellite point (the point on the earth directly below the satellite). At apogee, the antennas are likewise off axis in that they point at a spot on the earth slightly north and east of the subsatellite point.

By now I'm sure you're asking the question "why can't we just point the satellite at the earth at apogee and forget about it? Why is there so much maneuvering going on?" The reason again is rooted in the early days of OSCAR-10. Because the kick motor failed to ignite for a second burn, OSCAR-10 was trapped in its present 26-degree inclination orbit. Since the earth's axis tilts 23 degrees with respect to the ecliptic, or plane of the solar system, the sun never climbs beyond latitudes 23 North and 23 South (the Tropics of Cancer and Capricorn). If OSCAR-10 had made it to its intended 57-degree inclination, the (more slowly) changing argument of perigee would have brought the apogee latitude to a peak of 57 North, well into the northern hemisphere.

Once the apogee latitude is out of the tropics, it becomes impossible for the sun to shine directly on the top or bottom of the spacecraft (thus starving the solar arrays) when the spacecraft is pointed in a nominal direction, directly at the earth at apogee. In fact, the higher the apogee latitude for a Phase III satellite, the better. It would be ideal if a Phase III satellite such as OSCAR-10 could be parked directly above one of the poles, with its antennas pointed directly at the earth. In that spot, the sun would never shine more than 23 degrees off a direction perpendicular to the solar arrays, where the cells produce their maximum output. At the worst-case times, June 21 and December 21, 92 percent of the solar power would still be available.

Sadly, orbital mechanics does not allow a geostationary satellites to hang over the poles. So the next best thing is a part-time orbit, such as the Molniya. As long as the apogee latitude is sufficiently high, a Phase III-type spacecraft can satisfy the simultaneous requirements of keeping the antennas trained on the earth and the solar arrays pointed reasonably close to the sun.

Unfortunately, both Messrs. Murphy and Newton intervened (in that order), and OSCAR-10 is stuck in a low-inclination orbit with much more drastic excursions of sun angle along with some rather long eclipse seasons. The result has been a spacecraft that operates well for two seasons out of the year, when the sun is roughly perpendicular to the line of apsides and the solar arrays. However, the spacecraft requires significant off-pointing, and consequent degradation of service, in order to protect the solar arrays during the other two seasons.

There is a "beat" effect due to the combined motions of the earth around the sun, the motion of the OSCAR-10 apogee point, and the change of the OSCAR-10 RAAN, all cycles with different periods. In the late summer of 1985, these effects all added in phase, resulting in a predicted series of long apogee eclipses. A little thought shows that this would have resulted in unacceptable sun angles if the spacecraft had been left in its nominal orientation. If the sun went behind the earth at apogee, where the antennas would ordinarily point directly at the earth, the sun would then shine on the top of the spacecraft when-

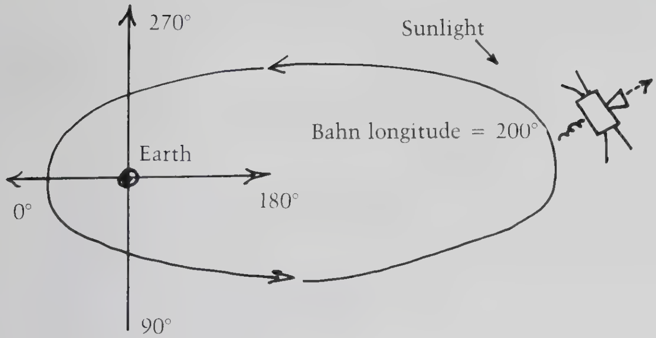


Figure 4

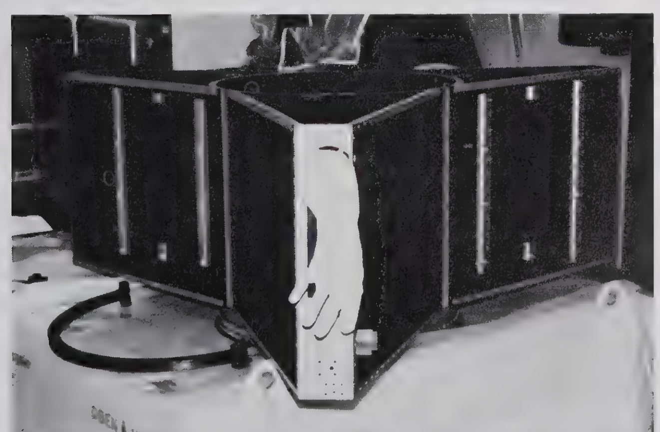
Because of eclipses, the Phase III spacecraft must be off-pointed to provide the best possible sun angle. In such cases the best user coverage will occur after apogee.

ever the spacecraft is out of eclipse. In that case, the solar arrays would never receive power.

The principle problem for command stations during those difficult times is to reorient the spacecraft so that the arrays receive sufficient solar energy. There is usually a choice of direction in which the spacecraft can be off-pointed to increase the available solar energy (Fig. 4). If the eclipses are long, the transponders must also be shut off at the appropriate times to keep the battery from deeply discharging.

It is easy to see that in the worst possible situation, where the sun shines directly on the antennas, any change will be an improvement! Therefore it is possible to make antenna coverage a secondary consideration when planning a reorientation. It is often possible to regain a satisfactory sun angle by reorienting the spacecraft only within the orbit plane, i.e., by keeping the bahn latitude near 0 degrees and varying the bahn longitude. If that is done, there will still be a point in the orbit at which the antennas point directly at the earth. That point simply won't occur at apogee. Useful communications can still go on, but for a smaller fraction of the orbit.

**Assistant Vice President for Engineering, Systems 25-B Hillcrest Road Warren, NJ 07060*



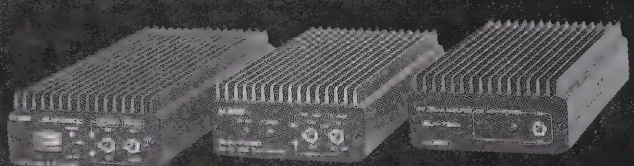
Comet
A protective glove covers the lens of the earth sensor on the Phase IIIC spacecraft, now under construction in Golden, Colorado.

ALM-203T List $345.00
2m FM Handheld Transceiver
Don't decide on a handheld until you have seen Alinco's newest! Lightweight, low spurious emission and powerful.

Transmit RF at 9.6V-Low Power = .4 watt
at 9.6V-High Power = 3. watt
at 13.8 V-Low Power = .5 watt
at 13.8 V-High Power = 5. watt

ALR-206T - List $345.00

- Unique Control Knob
- Completely Programmable From Microphone
- 25 Watt High - 5 Watt Low • 10 Channel Memory
- Built in Lithium Back Up Battery
- Up/Down Control On Microphone
- Built in Sub Audible Control
- Many Features, See Your Dealer



Linear Amps

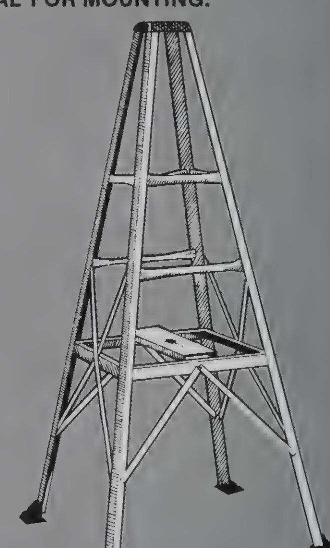
2m and 70cm Micro Linear Amplifiers. Each of these amps include a heavy duty heat sink, a protection circuit and low pass filter for a clean signal. On one you get a GaAsFET RX preamp and even an RF meter on one. List Prices From $69.95 to $156.00.

Power Supplies

Affordable performance is the final output of these work-horses. These high efficiency, high output, regulated supplies each comes with automatic current limit and shut down protection. Choose from 4.5 to 55 amps of output. List Prices From $69 to $333.

ALINCO ANNOUNCES THE PERFECT MATCH FOR MEDIUM SIZE ANTENNA SYSTEMS.
THE NEW ALINCO TOWERS ARE IDEAL FOR MOUNTING:

- Light-Weight Beams
- VHF UHF Antennas
- Oscar Antenna Systems
- Guy points when added support is required
- No rivets - all steel bolts
- All towers have *four* legs for easy mounting. Along with ALINCO's unique dual wall construction for unparalled strength
- Rotor mounts inside the ALINCO Tower with provisions for top mounted thrust bearing
- Light-weight aluminum construction for easy installation and durability



ALINCO MODEL AAZ-7 ROTATOR

ROTATOR
MODEL AAZ-7 $121.00

THRUST BEARING
MODEL AAZ-7A
$36.00

CONSTRUCTION OF LEGS

ALINCO ELECTRONICS

Contact your nearest dealer or Call Alinco for the location closest to you.

ALINCO ELECTRONICS
P.O. Box 20009 • Reno, Nev. 89515 Phone (702) 359-1414 • Telex 4993999 EGELECTR
44 Glen Carran Circle • Sparks, Nev. 89431 Facsimile (702) 359-1424

Graphics and Data Sparkle in Satellite Tracker Program

A new tracking package from Texas will please even the most discriminating satellite operator.

by Harold Winard, KB2M *

Personal computing has been an important part of amateur radio for the last several years and has had some practical effects on the amateur space program. The most popular use has been for tracking satellites. Although not impossible using simple tools and tables, manual tracking isn't an especially pleasant task either. Perhaps some hams have been dissuaded from involvement with satellite operation simply because they didn't know where and when the low-earth-orbiting satellites would pop up over the horizon. Others simply didn't have the time nor patience to use the mechanical or pencil-and-paper techniques required to determine when an OSCAR 6, 7, or 8 would be available over their part of the world.

The inexpensive personal computer and a powerful program developed by former AMSAT president Tom Clark, W3IWI, went a long way towards simplifying the task of tracking a satellite. In fact, during the late 1970s it added some practical fun to the use of newly acquired Northstar, TRS-80, or Apple computers.

The W3IWI program spawned a host of clones for use on all the popular personal computers, from the humble ZX-81 (Timex 1000) to some powerful minicomputers. In subsequent years the state of the software art was pushed ahead by several talented authors, including Roy Welch, W0SL, Ron Schwendt, N3AR, Bob McGwier, N4HY, and Vic Ruebhausen, W6WNK. All enhanced the basic W3IWI program, made it user friendly, and added a variety of features that allow the user to carefully chart the arrival of satellites, determine visibility windows towards selected stations around the world, and calculate the so-called pointing angle of the satellite's antennas.

As good as the programs were, a poll of AMSAT members several years ago showed an increasing desire for graphics. AMSAT authors responded with some flashy additions to the video screen. For example, the W0SL tracking program displays the locations of up to eight satellites simultaneously while scrolling through each spacecraft's vital statistics...subsatellite point, azimuth and elevation from the user, phase angle, etc.

The AMSAT programs, available from the AMSAT Software Exchange (P.O. Box 27, Washington, DC 20044), make satellite tracking easy and fun, and create some very impressive graphics to wow the family and visitors to the shack. With all this razzle dazzle from AMSAT, is there room for yet another tracking program? Does anyone need it and is it worth it? After using a pair of programs from Silicon Systems, Inc. (P.O. Box 742546, Houston, TX 77274-2546) I would answer the question with a resounding "Yes." Both programs, once available only directly from the authors, can now be acquired through the AMSAT Software Exchange.

GrafTrak II and Silicon Ephemeris, two complementary but separate programs, are the creation of Richard Allen, W5SXD, and Joseph Bijou, WB5CCJ. Dick prepared the astronomical algorithms and graphics while Joe worked on the original satellite tracking algorithms. No clone these. The programs are original and evince the three years of intensive work that went into their development.

What is GrafTrak II and Silicon Ephemeris? Attendees of the AMSAT-sponsored 1983 Space Symposium in Laurel, Maryland will recall that Dick demonstrated a prototype tracking and graphics program on a custom-built, graphics-oriented microcomputer. As the screen flashed orbital parameters in real time, including antenna pointing angles, the processor drew a picture of the earth as seen from the satellite...continents and all.

An impressive sight indeed, I thought, but not everyone knows how to build a custom computer or can afford one. Nevertheless, many visitors went away impressed, fantasizing about the day when they would have such powerful hardware and software at their disposal.

Dream no more. Owners of the IBM PC and many of its close clones can put their computers well into the space age with a Rolls Royce of tracking programs. GrafTrak II gives you professional-quality tracking graphics, including detailed views of the earth as seen from the satellite. The companion tabular data program, Silicon Ephemeris, will make your computer churn out reams of data on a satellite's past, present, and future positions.

For the amateur satellite user, the data will be as complete as you could possibly want. Even for the professional satellite engineer, the amount of infor-

mation that spews forth from Silicon Ephemeris will rival the data produced by some far more powerful machines. In fact, for many engineers the data will be sufficiently powerful and far less costly to produce than that from some professional packages.

Certainly GrafTrak II and Silicon Ephemeris are not for everyone. If you just want to know what time the satellite will be around for a Tuesday afternoon QSO, some of the $15 programs available from AMSAT will fill the bill just fine. But if the satellite bug has bit and held on fast, and you can justify the cost of the programs ($195 package price for both), the turbocharged programs from Texas will take you to new heights of satellite fun. In a sense, you will be sitting on top of the world, along with AMSAT-OSCAR 10 and any number of other satellites you choose.

What do you get?

Both programs are supplied on floppy disks affixed with rather modest white labels. GrafTrak II, the graphics-oriented program, comes on two disks. One contains the program and the other holds the massive data base required for the extensive and detailed maps. Silicon Ephemeris, the tracking program, comes on two disks. Both are identical but one is suitable for machines fitted with an 8087 math coprocessor chip. The other runs nicely, although somewhat more slowly, on a computer without the rather costly IC. The disks are protected by plastic baggies, a favorite packaging method of some budget software outfits. The bags aren't impressive but do the job of protecting the diskettes during shipping.

Documentation for the programs is typewritten (or produced on a letter-quality printer) and professionally printed in an 8-1/2-by-11-in. format. Although not as fancy as typeset manuals, the booklets are clearly written and take the first-time user quickly from the freshly-opened cardboard mailer to orbital calculations without too much distraction. A word of caution though. The documentation assumes a bit of computer savvy and familiarity with satellites and tracking. Anyone who has struggled with early versions of the W3IWI program or has been routinely running other programs, such as those for the Commodore 64 or Apple, should have little problem getting through the set-up information and the satellite terminology.

By far the flashier of the two offerings is the GrafTrak II graphics package. To run it you will need an IBM PC, XT, AT, or compatible. Two drives are a must as is the 8087 math chip. Also required are the PC-DOS 2.0 or greater operating system, an IBM color graphics display adapter or equivalent, and a minimum of 256 kbytes of RAM. The program will need at least 512 kbytes to make full use of all the options. Although its optional, an Epson FX-80 dot-matrix printer is handy for screen dumps of the graphic images.

Set up is simple and is similar to the standard procedures required to place the operating system onto the same disk as GrafTrak II. The program can be loaded from a floppy disk drive or from a hard disk for more convenient operation. Since the program is not copy protected you will want to make a copy for day-to-day use and store the original in a safe spot.

GrafTrak II is invoked from a command line that custom tailors the opening display for the satellite of greatest interest. For example, if OSCAR-10 is your favorite bird, the command line will include its descriptor along with other tokens that indicate the desired observer, the location of the map data (usually drive B), the type of printer, and the desired tilt. The last item, specified in degrees, makes the Earth appear tilted in the three-dimensional images. The authors suggest 23.5 degrees since that is the tilt as viewed from the plane of the solar system, called the ecliptic.

Other tokens determine whether the screen display will be intensified (recommended) or in monochrome (composite monitors only). For moonbouncers the operating frequency can be entered for automatic calculation of lunar Doppler shift. Options include entering the command line from the DOS prompt or using a batch file to automatically load the tokens.

Getting started

What happens when GrafTrak II is started? First the main program loads, usually from drive A, then the extensive map data is drawn from the other drive. After a rather long wait (the map data occupies almost 360 kbytes, or one complete diskette), the screen displays the current location of the satellite of choice as seen on a Mercator projection map (Fig. 1). The Macintosh-like screen also includes an area with data on the subsatellite latitude, longitude, height, range (distance from the observer to the spacecraft), beacon frequency (corrected for Doppler shift), the actual Doppler shift, and drift, that is the apparent change of the beacon's Doppler shift measured in Hertz per minute. Also in the display field are the elevation and azimuth angles from the observer, the orbit or revolution number, and the satellite phase. Key parameters are accompanied by up- or down-pointing arrows to indicate in which direction that value has moved since the last update.

The lunar display has its own set of descriptors, including the declination, Greenwich hour angle, right

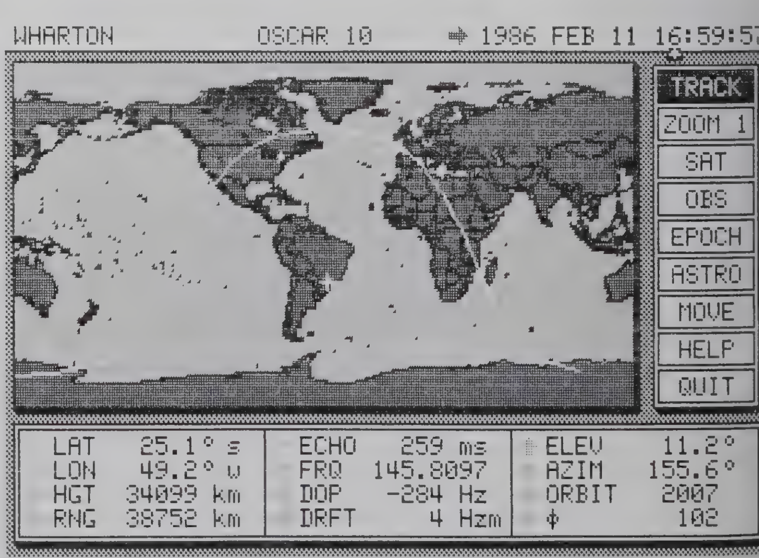


Figure 1

ascension, and horizontal parallax, and the percentage of the lunar disk that is illuminated. Echo is the time required for light to travel from the observer to the center of the Moon. Disg is the distance from the center of the Moon to the center of the Earth.

The solar and stellar display fields are similarly replete with information to precisely locate and track those objects. Even the amateur astronomer should find the data sufficient for all but the most stringent tracking requirements.

Taking charge

The user has access to several commands to zoom the image for a closer look at the subsatellite point, to change the satellite being tracked, to switch to another observation point (there are 16 total), and to change the current time forward or backward. The last feature is handy for quickly determining where a satellite was at some date in the past or will be in the future. A help key gives entree into several pages of information for those who don't like to reach for the manual but haven't yet mastered the command syntax.

One of the most reached-for keys is the one that invokes the three-dimensional image (Fig. 2). Instantly the track mode is replaced with a blue disk that indicates the horizon as seen from the satellite. The prime meridian is drawn first followed by the parallel at 90 degrees N. Parallels are then drawn every 20 degrees starting with 80 degrees S and ending with 80 degrees N. Meridians are drawn every 30 degrees.

After the grids are represented, the continental coastlines are drawn followed by the political boundaries. When the map is completed, the program waits for the command that will return it to the track mode or dump the image to the dot-matrix printer or a disk file. A nifty utility program is included with GrafTrak II that loads stored images in RAM and rapidly displays them in turn on the screen. The animation effect is quite good and gives an idea of what the Earth looks like in real-time as a satellite moves through its orbit.

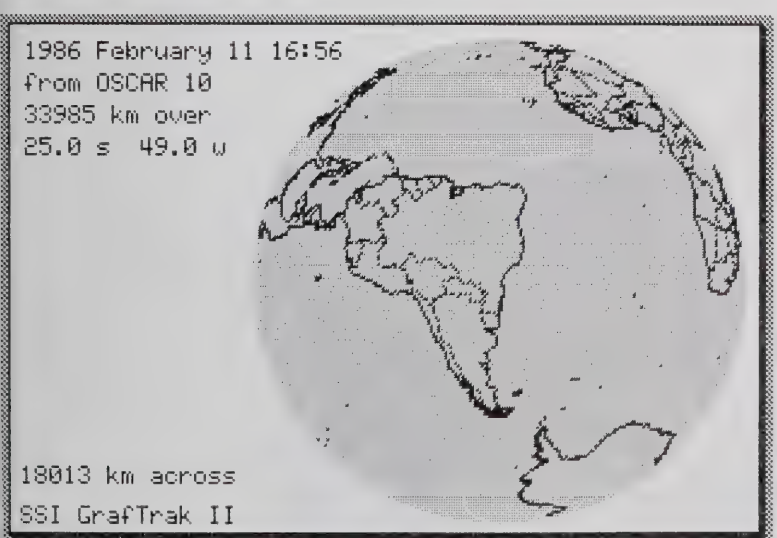


Figure 2

```
The Silicon Ephemeris    version 1.00
observers: Wharton/London

                        Wharton to London moonbounce

                        __Primary__    _Alternate_
______ utc ______       elev   azim    elev   azim    range   frac

Tue 18Feb86 23:00       66.1  118.3    44.1  257.7   401644   0.70
Tue 18Feb86 23:15       68.5  124.1    41.9  260.9   401618   0.70
Tue 18Feb86 23:30       70.7  131.0    39.7  264.0   401592   0.70
Tue 18Feb86 23:45       72.7  139.3    37.4  267.0   401565   0.70
Wed 19Feb86 00:00       74.3  149.3    35.1  269.9   401538   0.70
Wed 19Feb86 00:15       75.5  161.0    32.9  272.7   401512   0.70
Wed 19Feb86 00:30       76.1  174.1    30.6  275.5   401485   0.70
Wed 19Feb86 00:45       76.1  187.8    28.4  278.2   401458   0.70
Wed 19Feb86 01:00       75.4  200.8    26.1  280.8   401430   0.70
Wed 19Feb86 01:15       74.2  212.3    23.9  283.4   401403   0.71
Wed 19Feb86 01:30       72.5  222.1    21.8  286.0   401376   0.71
Wed 19Feb86 01:45       70.5  230.3    19.6  288.6   401348   0.71
Wed 19Feb86 02:00       68.3  237.1    17.5  291.2   401320   0.71
Wed 19Feb86 02:15       65.9  242.8    15.4  293.7   401293   0.71
Wed 19Feb86 02:30       63.4  247.6    13.4  296.3   401265   0.71
Wed 19Feb86 02:45       60.8  251.8    11.4  298.9   401237   0.71
Wed 19Feb86 03:00       58.1  255.5     9.4  301.5   401209   0.71
Wed 19Feb86 03:15       55.4  258.9     7.5  304.2   401180   0.71
Wed 19Feb86 03:30       52.7  261.9     5.7  306.8   401152   0.71
Wed 19Feb86 03:45       49.9  264.7     3.9  309.5   401124   0.71
Wed 19Feb86 04:00       47.2  267.3     2.3  312.3   401095   0.72
Wed 19Feb86 04:15       44.4  269.8     0.6  315.1   401066   0.72
Wed 19Feb86 04:30       41.7  272.1    -0.9  317.9   401037   0.72

 ---

Wed 19Feb86 17:30        0.1   53.0    50.8  111.8   399387   0.76
Wed 19Feb86 17:45        2.3   55.3    52.9  115.8   399353   0.76
Wed 19Feb86 18:00        4.6   57.5    54.9  120.1   399318   0.76
Wed 19Feb86 18:15        7.0   59.7    56.8  124.8   399284   0.77
Wed 19Feb86 18:30        9.4   61.9    58.6  129.8   399249   0.77
Wed 19Feb86 18:45       11.8   64.0    60.3  135.3   399214   0.77
Wed 19Feb86 19:00       14.3   66.1    61.8  141.2   399179   0.77
Wed 19Feb86 19:15       16.8   68.1    63.1  147.6   399144   0.77
Wed 19Feb86 19:30       19.4   70.2    64.3  154.5   399109   0.77
Wed 19Feb86 19:45       22.0   72.2    65.1  161.8   399073   0.77
Wed 19Feb86 20:00       24.6   74.2    65.7  169.5   399038   0.77
Wed 19Feb86 20:15       27.3   76.2    65.9  177.4   399002   0.77
Wed 19Feb86 20:30       30.0   78.2    65.9  185.3   398967   0.77
Wed 19Feb86 20:45       32.7   80.3    65.5  193.2   398931   0.77
Wed 19Feb86 21:00       35.4   82.4    64.9  200.7   398895   0.77
Wed 19Feb86 21:15       38.1   84.5    63.9  207.9   398859   0.78
Wed 19Feb86 21:30       40.9   86.7    62.7  214.7   398823   0.78
Wed 19Feb86 21:45       43.7   88.9    61.3  220.9   398787   0.78
Wed 19Feb86 22:00       46.4   91.3    59.8  226.7   398751   0.78
Wed 19Feb86 22:15       49.2   93.8    58.0  232.0   398715   0.78


(Copyright 1985 (C) Silicon Solutions)
                      object: Moon
```

Figure 3

Changing tracks

If you have at least 512 kbytes of RAM in your computer you can load the SED87 editor on top of GrafTrak without leaving the graphics program. The editor allows you to change the satellite file or enter new Keplerian elements. Full-screen editing, a nice feature of most professional word-processing programs, makes changing satellite elements fast and easy. New values can be entered without disturbing previous yet still-valid numbers. The escape key returns the program to the real-time tracking mode.

Graphics are nice but for long-range predictions Silicon Ephemeris fills the bill. Two disks are provided, one for use with an 8087-equipped computer and the other for machines without the math chip. For satellite calculations, the chip typically affords a 5-to-1 speed improvement; for solar and lunar calculations the IC can boost the speed more than ten times over the software-only math cruncher.

Regardless of the speed, the numeric data produced will be extensive. The user merely has to select the mode desired to determine the arrival time of all satellites to one observer or one satellite to all observers. To help plan future satellite operation, the user can create a schedule for one observer to a single satellite or determine the windows, or mutually-accessible times for two observers through one satellite. If detailed satellite tracking is not neces-

sary, the operator can simply determine the rise and set times of a satellite, say OSCAR-10, to plan the right times to be home and in front of the rig. A fascinating scheduling aid is mode 6, which gives the user a time-ordered alert of the arrival of all satellites.

Astronomy enthusiasts and moonbouncers will delight in an automatically produced almanac for either the Sun or Moon. For planning the best times for a moonbounce effort the window for two observers to the Moon can be quickly found (Fig. 3).

As with GrafTrak II, Silicon Ephemeris includes an editor to add, delete, or change information in either the observer or satellite files. All the commands are the same in each program and files can be easily swapped from one disk to the other to eliminate duplicate data entry.

---

*Editor, Satellite Journal
P.O. Box 575
Wharton, NJ 07885-0575

New Values Optimize Tracking Programs for 1986

by Dr. Tom Clark, W3IWI*

Your satellite orbital predictions may not run right in the new year if you don't add these new values to your W3IWI tracking program

The orbital prediction program I wrote a few years ago (published in Orbit magazine) has been translated by a number of collaborators and made available through the AMSAT Software Exchange (ASE). Most of the ASE versions have a table of sidereal times starting at 00:00 on January 0 of each year. That table expires at the end of 1985. This note updates the table for the entire period 1978 to 1999 using a more precise formulation than was used in the original program.

Recently the International Astronomical Union (IAU) adopted new astrometric constants based on the Julian day epoch Jan.0.0, 2000 (usually called J2000). The constants replace those based on the Bessilian year 1950 (called B1950). The new sidereal time calculations make use of the complete J2000 sidereal time series as published in the American Ephemeris and Nautical Almanac. The table gives the J2000 Greenwich Mean Sidereal Times (GMST) for January 0.0 of each year. The BASIC program that performed those calculations is given below. It is written in Microsoft BASICA and was run on an IBM-PC clone using MSDOS. The program includes a useful set of calendar utilities to relate calendar-day/day-of-year/day-of-the-week/elapsed-days since 1978.0. [Editor's note: Satellite Journal has received a similar sidereal time analysis program and table of values from Dr. Jack Cavanagh, KB4XF. Jack's values differ insignificantly from Tom's given above. We appreciate the fine effort of both experts.

Users of the AMS-81 Timex-Sinclair program should send a business-sized stamped and self-addressed envelope to Ralph Wallio, W0RPK, for update instructions. The address is RR# 4, Indianola, IA 50125.

Bob Rogers, W8JLE, advises that all versions of the W3IWI program running on Radio Shack computers, except the Model 4 QUIKTRAK program, require updates. The data statements can be found beginning on line 980 or 990, depending on the model.

The other versions of QUIKTRAK, as well as the VR-85 and W0SL programs do not require updates.]

Sidereal Time Calculations for January 0 at 00:00 UT
de W3IWI on Sun 850825 = 85 / 237

Year	*GMST*
78	*ø27584815*
79	*ø27518504*
80	*ø27452194*
81	*ø27659675*
82	*ø27593365*
83	*ø27527055*
84	*ø27460745*
85	*ø27668226*
86	*ø27601916*
87	*ø27535606*
88	*ø27469296*
89	*ø27676777*
90	*ø27610467*
91	*ø27544157*
92	*ø27477847*
93	*ø27685328*
94	*ø27619018*
95	*ø27552708*
96	*ø27486399*
97	*ø27693880*
98	*ø27627570*
99	*ø27561260*

```
                Sidereal Time Program

10 DEFDBL G-T : DIM DD$(21) : DD$="SunMonTueWedThuFriSat
20 ----------------------------------------------------------------
30 '
40 ' This program computes Greenwich Mean Sidereal Time at 00:00z Jan 0.0
50
60   Calculations are based on IAU "J2000" constants for maximum accuracy
70
80 ' It also demonstrates a nice calendar subroutine that may be of some use
90
100              de W3IWI      August 6, 1984
110
120 -----------------------------------------------------------------
130
140 PRINT "Sidereal Time Calculations for January 0 at 00:00 UT
150 ' Get current date and print table header
160 D$=DATE$ : Y=VAL(RIGHT$(D$,2)) : M=VAL(D$)   D=VAL(MID$(D$,4,2))
       GOSUB 1000
170 PRINT "  de W3IWI on "; DW$;Y*10000+M*100+D:" = ";Y;"/";DOY
180 PRINT : PRINT "Year","   GMST" : PRINT
190 ' LOOP TO COMPUTE Sidereal Time for Jan 0.0
200 FOR Y=78 TO 99 : M=1 : D=0 : REM -- Jan 0.0 of each year
210 GOSUB 1060
220 PRINT Y,   PRINT USING "0.########" ; GMST
230 NEXT   STOP
1000
1010        - - - -    - -       - - - - -
1020       - - - - Dates subroutine - - - -
1030     Input      Y = year (e.g. 83 for 1983)
1040                M = month
1050                D = day of month
1060     Output   DD = elapsed days since 1978.0
1070             DOY = day of current year
1080             DW$ = string with day-of-week
1090            GMST = Greenwich mean sidereal time in days at 00:00 UT
1100             STR = Sidereal time rate
1110          - -  - - - - - - - - - - - -
1120   DX = INT((Y-1)*365.25) : DD=INT(D) : Y=INT(Y) : M=INT(M)
1130   IF M>2
         THEN DD = INT((M + 1) * 30.6) + INT (Y * 365.25) + DD - 28553
         ELSE DD = INT((M +13) * 30.6) + DX + DD - 28553
1140   DN = DD/7   DN = INT (7* (DN-INT(DN))+.05)
1150   DW$ = MID$(DD$,3*DN+1,3)   DOY = DD - DX + 28125
1160   GMST = DD * .00273790931# + DD*DD * 8.05975D-16 + .278586056#
1170   GMST = GMST - INT(GMST) : STR = 1.00273790931# + 1.61195D-15*DD
1180 RETURN
1190
1200        -     - - - - - - - - - - - - .
1210       - - - - Inverse Date Subroutine
1220      Input.    DD = Elapsed days since 1978.0
1230 '  Output: Y,M,D = year,month and day
1240          and alby Date subroutine
1250       - -    - - - - - - - - - - - - - -
1260    - first calculate Year=Y and Month=M
1270   Y = INT ((DD + 731)/365.25) + 76
1280   M = ((DD + 28553 - INT(Y * 365.25)) / 30.61) - 1
1290     IF ( M>2.1  OR  M>2.06 AND Y/4=INT(Y/4))  THEN M=INT(M) ELSE M=1
1300   -- now get the day of the month=D
1310   TEMP = DD : D = 1 : GOSUB 1000 : D = TEMP - DD + 1
1320   -- finally, re-calculate everything and exit
1330   GOSUB 1000 : RETURN
1340 END
```

*President Emeritus
6388 Guildford Road
Clarksville, MD 21029

Starting Out: A Beginner's Guide

By Andy MacAllister, WA5ZIB*

Feedline problems constitute a considerable portion of the questions I receive each month from would-be satellite users. Since it is not easy to put a satellite rig at the antenna, and very few satellite enthusiasts use open-wire transmission lines, some type of coaxial cable is required. Differences in the type of installation, product availability, and money will determine which type of cable becomes part of your home station.

Of course, the shortest feedline from the shack to the antennas is best. Because of the VHF and UHF signals from AMSAT-OSCAR-10, line and connector losses at the ground station are a significant factor in how well you can receive that satellite's signals. Fortunately, ground-based satellite antennas needn't be very high. If they can peak above surrounding obstacles, and the coax run is 50 ft or less, you can achieve excellent results without excessive effort or cash.

Consider a typical uplink system on 435 MHz. A 100-W transmitter is connected to a 10-dB gain right-hand, circularly polarized antenna through 50 ft of RG-8/U coaxial cable. Assuming minimal loss through Type N connectors, the effective radiated power, or ERP, will be about 530 W. This installation owes its performance to the somewhat hefty coaxial cable and the use of low-loss Type N connectors. The performance would be significantly degraded if thinner RG-58/U cable was used and if common UHF connectors were installed at each cable termination. Incidently, those inexpensive connectors are also referred to by the designations Type M or PL-259. Ironically, at UHF, losses through so-called UHF connectors become prohibitive for all but the most noncritical installation.

With less power available, or with a longer cable run, a high-gain antenna and better coaxial cable become more important. Several well-known types, such as RG-213/U and RG-214/U, have the same loss characteristics as RG-8/U. Another 8/U type, Belden 8214, exhibits lower loss thanks to its cellular polyethylene foam dielectric between the inner conductor and the outer shield.

In contrast, common RG-8/U uses a solid polyethylene dielectric. In the typical installation described above, the use of 8214 coax would boost the ERP of the system to 600 W. For those striving for the best possible performance, Belden also manufactures a coaxial cable with a semi-solid polyethylene insulation and a combination of foil and braided shield. Our hypothetical installation equipped with this type 9913 coax would be able to boast an ERP of upwards of 730 W.

Type 9913 does not have the flexibility of other cables but has the advantage of very low loss. Because of its rigidity, the cable must be handled with care to prevent kinks. If a little care is taken to make large loops around rotators, to carefully route the cable from the antenna to the shack, and to prevent undue twisting forces at the connectors, 9913 can be almost as easy to use as other cable types.

Further on the road towards the ultimate is large-diameter 50-ohm hardline. However the cost of that rigid cable, plus the expensive special connectors it requires, can place it out of the reach of many hams. The most cost-effective choice, the one that best suits your needs and wallet, may be one of the 8/U style feedlines. But selecting from among those types means weighing more than just the cable attenuation. Other important factors, in addition to price, include life expectancy and the availability of connectors.

Most cables cost between 35 and 50 cents per foot with the exception of RG-214/U, which costs more due to its silver-coated inner conductors and shields. For survival, noncontaminating PVC jackets and solid polyethylene inner insulation, such as RG-213/U, RG-214/U, or Belden 9251, will last longer than others, especially when constantly exposed to water or directly buried. For most stations the environment wouldn't be that severe and standard PVC jacketing around cellular or semi-solid insulation will perform well for many years.

In any type of environment, it is important that the connectors be sealed against the elements. High-grade silicone rubber sealant, or a commercial product called Coax-seal are suitable for keeping moisture where it belongs, on the outside of the connector and not between the center conductor and the shield. For outdoor use, Type N connectors are a good choice since they are inherently weatherproof. Brand new Type N connectors are a bit pricey, between $3 and $5 each, but surplus dealers and those at swap meets usually purvey good quality connectors for about $2 each.

Until recently, the only reliable connector made specifically for 9913 was from Trompeter Electronics and cost about $16.50 each. Although the device clamps exceptionally well to the cable, the high cost inspired many to look elsewhere or attempt modifications to standard connectors. Amphenol recently introduced a connector for about $5 to $7 dollars each. Again, hamfest prices will be a bit lower.

A thorough investigation of coaxial cable types and connectors requires the aid of manufacturers' manuals and catalogs but the results can be well worth the time and effort. If you are planning a Mode L station for operation at 1269 MHz, an optimized system will reward you with stronger signals and more satisfying contacts. Even at 145 MHz, a good low-loss connection between equipment in the shack and the antennas is important. Mast-mounted preamplifiers can offset losses but not every satellite user can afford that accessory or will want to go through the effort required to mate them to an antenna on a lofty perch. Good quality coaxial cable and matching connectors can make the important difference.

* *2310 Romayor Court*
Pearland, TX 77581

de K2UBC

by Martin R. Davidoff, K2UBC*

Radio amateurs were working with OSCAR satellites for nearly two decades before AMSAT-OSCAR-10 was launched and the use of microcomputers for tracking became commonplace. The advent of the microcomputer brought changes in the way data for orbital predictions was disseminated. And OSCAR 10 has created a new interest in high-altitude satellites with long accessibility. However, low-altitude spacecraft in circular orbits continue to have appeal, especially to newcomers looking for an inexpensive way to get started in satellite communications. It's important not to overlook the needs of these beginners, and others, who require data for simple tracking techniques.

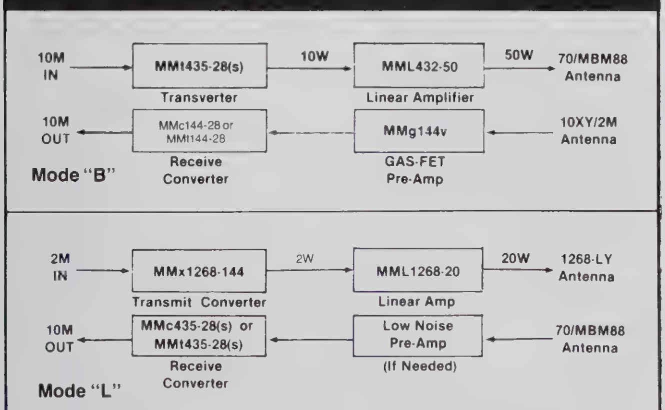
When I was working with OSCAR 6, I'd pick up new tracking parameters from an AMSAT net once every month or so. Used in conjunction with my hi-tech tracking equipment (a photocopy of a polar map found at the end of a dictionary plus a four-function hand-held calculator), tracking was a snap.

The only tracking information being disseminated then consisted of the time and longitude at which the subsatellite point crossed the equator heading north on a selected reference orbit. Using this information in conjunction with the nodal period (often referred to as "the period") and the increment (the shift in longitude of northbound equatorial crossing over two successive revolutions) it was easy to predict when the satellite would be in range for the next month or two.

Over the last year or so several amateurs using satellites in low-altitude circular orbits have reported that the old tracking methods no longer seem to work—i.e., their predictions are off by several minutes after a week or two. Let's find the cause of this mystery and see if we can find a solution.

After the launch of OSCAR 10 and the publication of Tom Clark's (W3IWI) BASIC tracking program (Orbit, No. 6, March/April 1981), the use of microcomputers for tracking greatly increased. The program employed sophisticated mathematical algorithms capable of handling satellites in most any orbit. Since the W3IWI program tracks low-altitude satellites, as well as those in highly elliptical orbits, it was natural to put aside the old tracking tools.

The inputs required for the W3IWI program consist of a set of six numbers called orbital elements. Two additional pieces of information are needed. One is the anomalistic period (not to be confused with the nodal period), which is the elapsed time between two successive perigees. Perigee is the low point in a satellites orbit. Since



Comet

AMSAT photographer Joe Flaska, WB0RLY, watches the birdie himself while Jan King, W3GEY, vice president for engineering, inspects the Phase IIIC spacecraft. The next AMSAT satellite is being constructed in laboratories in Golden, Colorado.

no orbit is ever perfectly circular, the definition applies quite well to both circular and nearly circular orbits.

The nodal period is the elapsed time between two successive ascending nodes of a satellite. An ascending node occurs when the subsatellite point crosses the equator headed north. The difference between the anomalistic period and the nodal period is small but becomes very significant for long-term predictions. For example, in October the Russian satellite RS-8 had an anomalistic period of 119.7051 minutes and a nodal period of 119.7616 minutes. The difference between the two periods, 0.0565 minutes or about 3.4 seconds, seems small. But let's see what happens if the wrong period is used for orbital predictions.

Since RS-8 makes about 12 revolutions per day, a projection roughly 24 hours in advance would be off by 40 seconds—not very good but tolerable. A projection two weeks in advance would be off by just over nine minutes—certainly not satisfactory. This brief calculation leads to a clear conclusion: The numerical difference between nodal period and anomalistic period is very significant in tracking. When working with the older tracking methods, be sure to use the nodal period.

There are several ways to obtain the nodal period for a satellite. The values listed in the table, which also includes longitude increment, will work for several years for most spacecraft. An exception is UoSAT-OSCAR 9. Its nodal period should be updated about four times per year. For the other scientific satellite, UoSAT-OSCAR 11, an update once per year would be desirable. Other sources for information about the nodal period and longitude increment include Satellite Journal, Amateur Satellite Report, and the AMSAT HF nets.

Those who insists on using the latest up-to-date data can always compute the nodal period from the current orbital elements (see "Orbital Elements" in this issue). The following step-by-step procedure (with reference to the table) shows how it's done.

Step 1

Collect input data for the satellite of interest.

This consists of appropriate rows from the table and the orbital parameter called "mean motion," selected from the current set of orbital elements.

Step 2

Add the value of the mean motion to the rate of change of the argument of perigee, in revolutions per day (also in the table.

Step 3

Take the inverse of the result of Step 2. That will be the nodal period in units of days per orbit.

Step 4

Multiply the previous answer by 1440 minutes per day. The result is the nodal period in minutes per orbit.

(Continued next page)

(Continued from previous page)

A numerical example using data for OSCAR 11 yields Step 2 14.619942 + (-0.008686) = 14.611256 Step 3 1/14.611256 = 0.068440 Step 4 (0.068440) X (1440) = 98.554156

Once all the values for nodal period and longitude increment have been found, you will still need the time and longitude at the ascending node during a reference orbit in order to proceed with your predictions. With the reference orbit data you will be able to predict future ascending nodes for a month or two with reasonable results—to better than 1 minute in time and 0.25 degree in longitude. Predictions using simple methods and based on a single reference orbit for longer times are not feasible. In fact, those working on the Project OSCAR Orbital Calendar use much more sophisticated methods and are hard pressed to produce reliable predictions for an entire year, especially for satellites such as OSCAR 9, which is in a very low orbit.

Reference-orbit data can be obtained aperiodically from AMSAT publications and nets and is a regular feature of the American Radio Relay League's (ARRL's) W1AW bulletins (see QST for the schedule). Anyone with a microcomputer using the W3IWI program, or one of the many spin-offs available from the AMSAT Software Exchange, can generate reference orbit data from the latest orbital element set. If you need data in the reference-orbit format, try locating a cooperative local amateur using a microcomputer for tracking. If you do your tracking on a microcomputer, try to make reference-orbit data available to those who need it.

That's it for this issue. I hope I've cleared up more mysteries than I've created.

**13803 Manor Glen Road*
Baldwin, MD 21013

W 6 Space Philosopher

by John Browning, W6SP, Chairman of the Board*

One of the things I've learned working for AMSAT is that it helps to have a thick skin. In the free world, all elected officials are fair game for both reasonable and unreasonable criticism. I clearly recognize criticism when I hear it. Deciding whether it is reasonable or unreasonable, is more difficult. In reacting to unfavorable comments, I try to maintain objectivity. I also try not to be defensive. For one thing, it is difficult to defend oneself against legitimate criticism. Associates sometimes tell me I am absent-minded. This certainly comes under the heading of criticism. Is it reasonable? Probably not. At least, I don't remember ever having forgotten anything important.

Several years ago, I was selected to take charge of a facility that is responsible for on-orbit control of numerous government spacecraft. In the process of learning about the complexities of control-center operations from those more experienced in such matters, I frequently asked the question, "Why do we do it this way?" The standard answer was, "We have always done it this way!" Word soon got around that I considered the standard response inadequate. Then, I started hearing, "It's your policy!" Son of a gun! What could I say? I couldn't remember having established any policies.

To avoid a repetition of this particular embarrassment, I have implemented a personal AMSAT policy. I look for the humorous side of our rather serious business. Most of the time, when humor is found, laughter results and enjoyment sets in.

My biggest chuckle, so far, came from a letter containing a very specific and reasonable complaint. It was written by a disgruntled holder of an American Radio Relay League (ARRL) DX Century Club award. He has been recognized for having made contacts with amateur stations in one hundred countries through Phase II satellites. The writer is one of the very few operators who have achieved this distinction. The two principal ingredients of his remarkable success were diligent employment of keen operating skills over a period of several years, and living in one of the few areas of the world from which "seeing" one hundred countries through a low altitude satellite is physically possible.

As previously reported, the AMSAT Board struggled long and hard before recommending extension of award eligibility to include high-altitude satellite contacts. It was a difficult decision since the pros and cons were nearly balanced. Our carefully considered action caused the writer to comment, "The inmates have taken over the asylum."

The inmates received some reasonable criticism for our conduct of the initial planning for the 1985 annual meetings. We created a problem by trying too hard to be fair. We

received separate offers from two Texas centers of excellence, Dallas and Houston. Our selection process became overly formalized. Before a decision was reached, both groups ran out of time to do the first-class job each was capable of doing. Fortunately, our Boulder bunch was able to pick up the pieces and come up with superb arrangements for the Vail, Colorado site.

There is substantial membership support for moving the meetings around the country. We plan to continue that practice. We have standardized on the US Veterans Day holiday weekend (early November) for our annual gatherings. Future location decisions will, hopefully, be made well in advance. Completion of adequate arrangements requires a substantial effort on the part of local area people. So far, there has been no shortage of competent volunteers for this duty.

A critical review of the 1985 meetings produced both favorable and unfavorable comments. The former greatly outnumbered the latter. There were some suggestions to locate future meetings somewhere within the temperate zone. Those of us who found ourselves driving through 11,000-ft Loveland Pass during the onset of a weekend blizzard, concur. On the other hand, snow-covered Vail was spectacularly beautiful. Most AMSAT members stayed close to the cozy fireside of the elegant Westin Hotel. However, numerous self-assertive wives ventured forth into the snow each day. They diligently verified the high-altitude performance of various credit cards in the local village shops.

Total member attendance was down from 1984 but, for the first time, all seven members of the board of directors were able to participate in the symposium as well as the general and board meetings. The "good humor" policy was almost universally observed. During an informal Friday dinner at an "typical" Vail restaurant, our good cheer was quite evident to everybody within earshot. The inmates became downright gleeful. Afterwards, I had trouble getting to sleep because my sides were sore from laughing. Just like they say, we have a lot of funny people in our organization!

Certainly among the funniest is our vice president for operations, Julian Macassey, N6ARE. For one entire day, he kept us entertained as he skillfully conducted the well-organized, third annual technical symposium. Julian has often been unreasonably criticized for his quaint manner of speech. In rebuttal, he repeatedly assures us his accent is considered quite proper in countries where motorists are intelligent enough to drive on the correct (i. e., left) side of the street.

There was absolutely no criticism of the person in charge of the 1985 show. Molly Hardman, N3CHZ, both organized and supervised the smooth-running performance. She accrued a bountiful number of completely reasonable compliments. We thank Molly for enabling us to conduct our AMSAT functions in beautiful surroundings, in a thoroughly enjoyable manner.

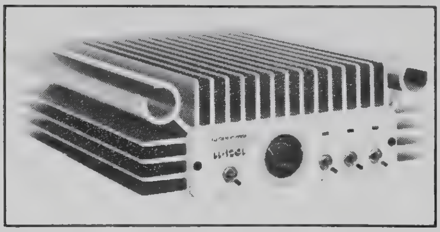
I hope I remember to attend next year! 73, John, W6SP

*6202 Lochvale Dr.
Rancho Palos Verdes, CA 90274

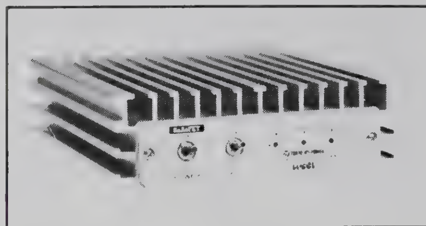
TOKYO HY-POWER LABS, INC.

UHF AMPLIFIERS

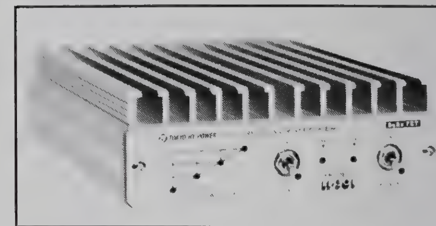
HL-120U



HL-60U



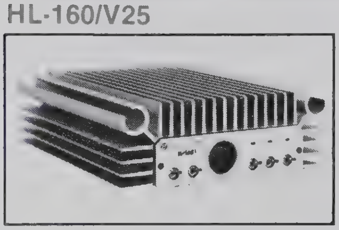
HL-30U



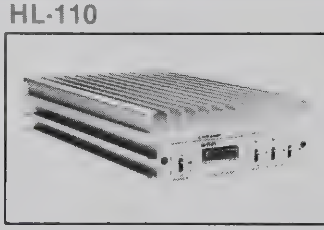
MODEL	HL-120U UHF SSB/FM/CW AMPLIFIER 100 WATT	HL-60U UHF SSB/CW/FM AMPLIFIER 60 WATT	HL-30U UHF SSB/CW/FM AMPLIFIER 30 WATT	HL-20U HUF SSB/FM AMPLIFIER 20 WATT	HL-30V VHF FM AMPLIFIER 25 WATT
Sugg. Retail	$399.95	$249.95	$149.95	$129.95	$76.95
Description	430 MHz band all mode amp with low noise GaAsFET type preamplifier. Low-loss 'N' connectors. Oscar ready!	430 MHz band all mode amp with low noise GaAsFET type preamplifier. Plenty of punch for portable OSCAR.	430 MHz band all mode amp with low noise GaAsFET type preamplifier. The optimum level for UHF mobile.	430 MHz gain block amp Power for mobile, base and ATV.	VHF multi-purpose amplifier for SSB or FM. ECONOMICAL Best Buy in $/Watt.
Frequency Range	430-449.995 MHz	430-449.995 MHz	430-449.995 MHz	430-449.995 MHz	144-148 MHz (Export 150 MHz avail)
Modes	SSB, CW, FM, TV	SSB, CW, FM, TV	SSB, CW, FM	SSB,CW,FM	FM
Supply Volts @ Amps	DC + 13.8V @ 17-19 A	DC + 13.8V @ 9 amps	DC + 13.8V @ 5 AMPS	DC + 13.8V @ 4 AMPS	DC + 13.8V @ 4 Amps
R.F. Power-Out (AVG)	100W	50 Watts	30 Watts	20 Watts	25 Watts
R.F. Power-In (NOM)	12 Watts	12 Watts	2 Watts	3W or 100mW (selected internally)	2.5 Watts
Connector In/Out	TYPE 'N'	TYPE 'M'	TYPE 'M'	TYPE 'M'	TYPE 'M'
Pre-amp Type	GaAsFET	GaAsFET	GaAsFET	NONE	N/A
Output Meter Type	LIGHTED METER	N/A	L.E.D.	NONE	N/A
Dimensions	218W × 82H × 299D m/m	150W × 45H × 164D m/m	100W × 35H × 170D m/m	100W × 30H × 158D m/m	100W × 30H × 158D m/m
Weight	3.5 Kg	1.2 Kg	550g	520g	520g

VHF LINEAR AMPLIFIERS

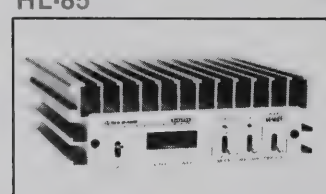
HL-160/V25



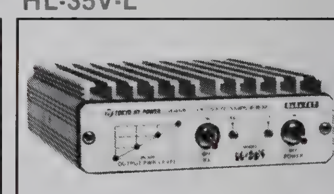
HL-110



HL-85



HL-35V-L



MODEL	HL-160V and HL-160V25 VHF 160W OUTPUT METER PREAMP	HL-110V VHF AMP 100 WATTS OUTPUT METER PREAMP	HL-85V VHF 80 WATT GaAsFET PREAMP METERING	HL-62V VHF SSB/FM AMP, GaAsFET PREAMP	HL-35V/L VHF FM/SSB AMP 25 WATT GaAsFET PREAMP
Sugg. Retail	$379.95 HL-160V $299.95 HL-160V25	$259.95	$189.95	$169.95	HL-35V $89.95 HL-35V/L $99.95
Description	144 MHz all mode amp with low noise FET type preamplifier. 160 Watts out from 3, 10, Watts with 160V (25 W 160V25)	144 MHz all mode with MOS-FET preamp	144 MHz all mode amp with low noise GaAsFET type preamplifier. 80 Watts Output with 10 W drive.	144 MHz all mode amp with GaAsFET type preamplifier.	VHF multi-purpose amplifier for SSB or FM. ECONOMICAL Best Buy in $/Watt with SSB capability and GaAsFET PRE-AMPLIFIER.
Frequency Range	144-148 (Export Available 150-160 MHz)	144-148 MHz	144-148 (Export Available 150-160 MHz)	144-148 MHz	144-148 MHz
Modes	SSB, CW, FM	SSB,CW,FM	SSB, CW, FM	SSB, CW, FM	FM(35V) FM/SSB/CW (35V/L)
Supply Volts @ Amps	DC + 13.8V @ 23A (V25: 22A)	DC + 13.8V @ 15 AMPS	DC + 13.8V @ 12 amps	DC + 13.8V @ 7.5 A	DC + 13.8V @ 4 Amps
R.F. Power-Out (AVG)	160W	100 Watts	80 Watts	60 W	25 Watts
R.F. Power-In (NOM)	3 or 10 (V25: 25W)	10 Watts	10 Watts	10 Watts	2.5 Watts
Connector In/Out	TYPE 'M'	TYPE 'M'	TYPE 'M'	TYPE 'M'	TYPE 'M'
Pre-amp Type	F.E.T.	MOS-FET	GaAsFET	GaAsFET	GaAsFET
Output Meter Type	LIGHTED METER	LIGHTED METER	LIGHTED METER		L.E.D.
Dimensions	218W × 82H × 299D m/m	172W × 60H × 263D m/m	172W × 60H × 184D m/m	150W × 45H × 164D m/m	100W × 35H × 150D m/m
Weight	3.5 Kg	2.2 Kg	2.0 Kg	1.2 Kg	520g

ENCOMM

1506 Capitol Avenue, Plano, Texas 75074
Phone (214) 423-0024 GI I I FAX (214) 423-0081

The Digital Front

by Harold Price, NK6K*

If you've been reading the UoSAT-OSCAR-9 and 11 bulletins, you know that I recently spent three weeks at the University of Surrey working on software and procedures for the UO-11 Digital Communications Experiment. Jeff Ward, K8KA, was there as well, beginning his two-year tour of duty overseas to work on the DCE and other UoSAT satellite projects. During those three weeks, Jeff and I implemented, tested, and uploaded new DCE message software. This version supports large message transfer between several gateway stations and will be integrated into the current terrestrial message system in the coming weeks.

Jeff and I also carried out a cultural exchange mission. It seems that the British get most of their impressions of Americans from the "telly," where such in-depth introspective imported studies as "Starsky and Hutch" and "Joanie Loves Chachi" are prime time fare. If it weren't for "Benny Hill," Jeff and I could never have held our heads up. I also saw an advertisement in The London Times that said "We can sell anything; Sand to the Arabs, snow to the Eskimos, and doughnuts to the Americans." Harhumph.

I also had to explain American football; why they called that bloke "Refrigerator," and why the "get near the goal and give the ball to the largest thing on the field" play was such a new concept.

JAS-1

Here are more specifications for JAS-1, received from Harry Yoneda, JA1ANG, at the November AMSAT General Meeting. All items are approximate.

Launch Date: mid August 1986

Orbit: Altitude: 1500 km, circular, non-sun synchronous Period: 120 minutes Inclination: 50 degrees

Shape: 26-facet polyhedron 40 cm by 40 cm by 47 cm (see cover of Satellite Journal, No. 6)

Weight: 50 kg

Beacons: JA (J-analog) 435.795 MHz 100 mW CW/PSK JD (J-digital) 435.910 MHz 1 W PSK

Transponders: JA - Linear, Inverted Uplink Passband: 145.9 - 146.0 MHz Downlink Passband: 435.9 - 435.8 MHz Bandwidth (-3db): 100 kHz Power: 1 W pep Required uplink Power: 100 W eirp

JD - 1200-baud digital, AX.25 level 2/version 2 Uplink channels: 145.85, 145.87, 145.89, 145.91 EPMHz Uplink modulation: Manchester-II code, Biphase level FM Downlink channel: 435.91 MHz Downlink modulation: NRZI, PSK Power: 1 W Uplink power required: 100 W eirp UO-11 DCE

As stated above, a new software package has been installed onboard the UO-11 DCE. The DCE message system, called MSG2, provides for 96 kbytes of onboard message storage. A single message can have a maximum of 16 kbytes. Up to 128 messages can be stored.

Because the DCE is only one of several experiments on UO-11, memory storage is limited, and the command and message frequencies are shared, direct access to the DCE is limited to gateway stations. However, we hope to give everyone experience with low earth orbit store-and-forward mailboxes by integrating MSG2 with ground-based networks. This is currently done by hand. For example messages to K8KA or G3YJO are sent through the W0RLI HF network to KD6SQ, where they are removed, packaged, and sent to the DCE manually. This process will be automated in the near future.

Three gateway stations are planned for the US, one on the East Coast at WA9FMQ, one in Dallas (N5BRG/WD0ETZ), and one here on the West Coast. The West Coast station is operational, the other two began transmission tests in the last week of 1985, and will be running by the time you read this.

Equipment for gateway stations in JA, VK, and ZL will ship as soon as the Dallas crew finishes testing it. The experience gained by the DCE gateway stations will be used to help integrate JAS-1 and PACSAT into the network when they become available. Both of those spacecraft will also support direct user access.

The following information is provided for those stations who wish to monitor the DCE activity directly.

The DCE, like most of the experiments on UO-11, uses 8-bit asynchronous serial data, with one start bit and two stop bits. This is decodable with a standard UART; it is not bit-stuffed NRZI as is found on packet radio TNCs. All data from the DCE is sent in blocks. A block starts with a hex 10 03. The 10h character is called a DLE (data link escape), and is special. The character preceding the block start DLE is never another DLE. If a DLE is part of the data in the rest of the block, a second DLE is inserted after the CRC is computed. On reception, two DLEs are replaced by one before the CRC is computed.

The rest of a block looks like this:

Field Length Meaning
cmd 1 byte type of block
255-cmd 1 byte inverse of cmd
len 1 byte length of data
data len data, may be zero length
crc1 1 byte low order CRC byte
crc2 1 byte high order CRC byte

The CRC bytes are computed by the following algorithm on a Z-80.

; ; Compute CRC on character in A into HL

```
; CKSUM:
 LDB,8
 LDC,A
 CRC2:
 LDA,C
 RLCA
 LDC,A
 LDA,L
 RLA
 LDL,A
 LDA,H
 RLA
 LDH,A
 JRNC,CRC4
 LDA,H
 XOR10H
 LDH,A
 LDA,L
 XOR21H
 LDL,A
 CRC4:
 DECB
 JRNZ,CRC2
 RET
```

Block types of interest in this short discussion are:

T - Title block. The title of each active message is sent one at a time when the DCE is "idle." The data field contains one byte of message number, one byte of message length/64, and then the title. Message numbers larger then 128 mark messages that have not been completely loaded. The title for message zero contains DCE hardware and software status values.

D - Data block. Messages are downlinked in 64-byte blocks. The data field consists a 1-byte block number (0-255), and 64 bytes of data.

B - Bit Map. Uplinked blocks are acknowledged with a bit map. The data area consists of one byte of message number, and from 1 to 32 bytes of bit map. These bytes are viewed as a bit array indexed by block number. A one bit means the corresponding block entered, bit maps are sent until all block has been correctly received.

The scheme of blocks and bit maps versus an AX.25-type link layer was chosen for several reasons. For this phase of operations, DCE access will be limited to one user at a time. Only the file transfer service is offered. Many stations will be half duplex. Also, the code needed to implement this protocol was very small, only 2.2 kbytes was required. The code also includes memory/file management, and routines to scan the hardware protected memory for single-bit errors.

More sophisticated protocols permitting full-duplex data transfer may be developed in the future. The DCE is switched into the standard UO-11 round-robbin display at regular intervals, title blocks are usually seen. Watch the UO-9 and UO-11 bulletins for continuing information.

An RS-232-C inverter

As stated in Satellite Journal No. 4, the data downlinked by the UO-11 145.825-MHz FM downlink is Bell-202 inverted, that is, the sense of mark and space are reversed. The following is a very sleazy way to invert the data. It's ugly, but it's what I had in the junk box, and it works on my generic S-100 CP/M hardware and on the IBM-PC. Use a 1489 IC (available from Radio Shack) and make the following connections: pin 1 - data input; pin 3 - Inverted Data Out; pin 7 - ground; pin 14 - +12 V. Connect the data input (pin 1) to the RS-232-C data output of any Bell-202 modem. Connect pin 3 to your computer's serial port. This will work with any serial-port computer that is willing to accept ground as something other than +12 V.

A solution that provides both positive and negative voltages can be had from a 741 op-amp. Hook it up as an inverting amplifier with infinite feedback.

** 1211 Ford Ave.
Redondo Beach, CA 90278*

More on JAS-1, UO-11 DCE - Message transfer begins, and an RS-232 inverter for UoSAT reception.

Satellite Journal is the very best way for AMSAT to keep its readers informed about the latest developments in the radio amateur space program. It's a vital link to the satellite user that relies on the goodwill of its advertisers.

When you call or write one of those manufacturers or retailers, tell them you saw their advertisement in *Satellite Journal.* You'll help demonstrate the importance of the satellite community and also ensure our continued growth and service to the membership.

Artwork by Pamela Lee

AMSAT NEWS

Ohio station claims first Mode L WAC

An Ohio operator, Ron Vanke, K8YAH, has claimed the first Mode L Worked All Continents award. However, Ron is not sure if it's a first. Ron says he completed the feat in early December 1985 when he worked ZL2AQE. Others Ron claims in his would-be first WAC are K0RZ, DL3ZM/YV5, DL9GU, ZS6AXT, and JR3BRS.

Can anyone claim achieving Mode L WAC earlier than December 10, 1985?

SAREX-2 software passes with flying colors.

According to Ralph Wallio, W0RPK, the first test of SAREX-2 software was a success. The ROM-based software was taken aloft in a light aircraft over Iowa on December 11, 1985. Over 500 messages were logged in the one-hour flight. Although the flight was cut short by aircraft mechanical problems, the software proved "bullet-proof" under the load stress of several hundred simultaneous users. This test was designed to model the heavy loads expected when SAREX-2 flies aboard the shuttle this year.

Event to Celebrate 100th Anniversary.

A special callsign has been issued to celebrate the 100th anniversary of the city of Johannesburg, South Africa. The call, ZS6JCF (Johannesburg Centenary Festival), will be used throughout 1986. Watch for ZS6JCF on AMSAT-OSCAR-10 Mode B between 1200 and 1500 UTC. Mode L activity will be announced later. A special gold-leafed QSL card will be issued for all satellite contacts.

RS-9 and RS-10 Ready For Launch

Two Russian amateur satellites, RS-9 and RS-10, are complete, tested, and ready for launch, according to Pat Gowen, G3IOR. Pat bases his forecast on information received from Leo Labutin, UA3CR.

It now appears the two spacecraft will be launched separately sometime during February. The RS-10 Mode T downlink passband will extend from 145.957 to 145.997 MHz with beacons at both ends. The uplink will apparently be in the vicinity of 21.26 to 21.30 MHz. The UHF beacon at 435.395 MHz remains unlicensed and may not be turned on immediately.

NASA nixes ACTS transponder

In a letter to AMSAT engineering vice president Jan King, NASA ACTS program manager Daniel L. Brandel says that there is no possibility of an AMSAT transponder on that division's planned communications satellite. ACTS, or Advanced Communications Technology Satellite, is targeted for a 1989 launch.

Although the concept of an AMSAT transponder on the geosynchronous spacecraft prompted some thought by AMSAT officials, Brandel told King that "the program currently has a very tight budget and 1989 launch schedule, and the current spacecraft and communications payload design constraints, e.g. weight, mass properties, thermal, power, and RF characteristics, will not permit the addition of a transponder to the spacecraft. Additions of major payloads such as your transponder, which do not have currently completed technical studies on their impact on the spacecraft, inject a significant cost growth and schedule risk into the program."

Phase III Satellite Operations Manual Available

The AMSAT Phase III Satellite Operations Manual is now available. In easily understood terms it explains many of the intricacies of working OSCAR-10. The graphic presentations of the orbits and the definitions of terms are especially helpful. The manual has been published in conjunction with Project OSCAR. It is available now from AMSAT headquarters for a $15 donation. Write to AMSAT, P.O. Box 27, Washington, DC 20044.

1986 Orbital Prediction Book Available

The 1986 edition of the Project OSCAR orbital prediction book features two Russian satellites, RS-5 and RS-7, as well as UoSAT-OSCAR-9, OSCAR-11, and AMSAT-OSCAR-10. For the low-earth orbiters, the calendar includes the time and longitude for all ascending nodes. For OSCAR-10, the calendar presents the time and sub-satellite point for each apogee and the argument of perigee. The 1986 calendar is available from Project OSCAR for a minimum donation ($10 in North America, $12 elsewhere). Address inquiries to Project OSCAR, P.O. Box 1136, Los Altos, CA 94023.

Orbital Elements

Satellite:	**oscar-9**	
Catalog number:	12888	
Epoch time:	85333.13677406	
Fri Nov 29	03:16:57.278	1985 UTC
Element set:	817	
Inclination:	97.6440	deg
RA of node:	324.7850	deg
Eccentricity:	0.0004089	
Arg of perigee:	64.3834	deg
Mean anomaly:	295.7795	deg
Mean motion:	15.27803874	rev/day
Decay rate:	1.347e-05	rev/day'2
Epoch rev:	23041	
Semi major axis:	6857.481	km
Anom period:	94.252936	min
Apogee:	499.220	km
Perigee:	493.612	km
Ref perigee:	2889.14845031	
Fri Nov 29	03:33:46.107	1985 UTC
Beacon:	145.8250 MHz	

Satellite:	**oscar-10**	
Catalog number:	14129	
Epoch time:	85334.62615197	
Sat Nov 30	15:01:39.530	1985 UTC
Element set:	213	
Inclination:	26.3257	deg
RA of node:	107.1274	deg
Eccentricity:	0.5978241	
Arg of perigee:	65.8075	deg
Mean anomaly:	344.0753	deg
Mean motion:	2.05855566	rev/day
Decay rate:	1.8e-07	rev/day'2
Epoch rev:	1857	
Semi major axis:	26105.506	km
Anom period:	699.519585	min
Apogee:	35337.361	km
Perigee:	4124.360	km
Ref perigee:	2890.64764047	
Sat Nov 30	15:32:36.136	1985 UTC
Translate freq:	581.0047 MHz	
Invert:	1	
Beacon:	145.8100 MHz	

Satellite:	**oscar-11**	
Catalog number:	14781	
Epoch time:	85331.63017814	
Wed Nov 27	15:07:27.391	1985 UTC
Element set:	100	
Inclination:	98.1752	deg
RA of node:	36.1442	deg
Eccentricity:	0.0014738	
Arg of perigee:	74.2749	deg
Mean anomaly:	286.0085	deg
Mean motion:	14.62007678	rev/day
Decay rate:	1.08e-06	rev/day '2
Epoch rev:	9291	
Semi major axis:	7061.913	km
Anom period:	98.494695	min
Apogee:	713.590	km
Perigee:	692.774	km
Ref perigee:	2887.64423634	
Wed Nov 27	15:27:42.19	1985 UTC
Beacon:	145.8260 MHz	

Satellite:	**RS-5**	
Catalog number:	12999	
Epoch time:	85331.15032509	
Wed Nov 27	03:36:28.87	1985 UTC
Element set:	280	
Inclination:	82.9620	deg
RA of node:	216.3799	deg
Eccentricity:	0.0009495	
Arg of perigee:	94.1541	deg
Mean anomaly:	266.0578	deg
Mean motion:	12.05056989	rev/day
Decay rate:	4e-08	rev/day'2
Epoch rev:	17353	
Semi major axis:	8033.824	km
Anom period:	119.496423	min
Apogee:	1684.261	km
Perigee:	1669.005	km
Ref perigee:	2887.17197971	
Wed Nov 27	04:07:39.47	1985 UTC

Satellite:	**RS-7**	
Catalog number:	13001	
Epoch time:	85328.64373215	
Sun Nov 24	15:26:58.457	1985 UTC
Element set:	225	
Inclination:	82.9586	deg
RA of node:	212.1605	deg
Eccentricity:	0.0023324	
Arg of perigee:	23.9560	deg
Mean anomaly:	336.2560	deg
Mean motion:	12.08693862	rev/day
Decay rate:	4e-08	rev/day'2
Epoch rev:	17375	
Semi major axis:	8017.690	km
Anom period:	119.136867	min
Apogee:	1661.718	km
Perigee:	1624.317	km
Ref perigee:	2884.64918891	
Sun Nov 24	15:34:49.922	1985 UTC

Satellite:	**NOAA-8**	
Catalog number:	13923	
Epoch time:	85306.13057229	
Sat Nov 2	03:08:01.445	1985 UTC
Element set:	125	
Inclination:	98.6532	deg
RA of node:	335.4894	deg
Eccentricity:	0.0017597	
Arg of perigee:	40.0275	deg
Mean anomaly:	320.2196	deg
Mean motion:	14.22476506	rev/day
Decay rate:	4.6e-07	rev/day'2
Epoch rev:	13497	
Semi major axis:	7192.279	km
Anom period:	101.231900	min
Apogee:	835.436	km
Perigee:	810.123	km
Ref perigee:	2862.13834051	
Sat Nov 2	03:19:12.620	1985 UTC
Beacon:	137.5000 MHz	

Satellite:	**NOAA-9**	
Catalog number:	15427	
Epoch time:	85304.76155037	
Thu Oct 31	18:16:37.951	1985 UTC
Element set:	44	
Inclination:	98.9641	deg
RA of node:	258.2335	deg
Eccentricity:	0.0016504	
Arg of perigee:	75.9676	deg
Mean anomaly:	284.3328	deg
Mean motion:	14.11387372	rev/day
Decay rate:	9.8e-07	rev/day'2
Epoch rev:	4560	
Semi major axis:	7229.947	km
Anom period:	102.027270	min
Apogee:	883.374	km
Perigee:	859.509	km
Ref perigee:	2860.77644257	
Thu Oct 31	18:38:04.638	1985 UTC
Beacon:	137.5000 MHz	

Reference Orbits

Note: East longitudes are positive; west longitudes are negative.

Sunday December 8, 1985

oscar-9

Sun Dec 8	01:03:27.60	1985 UTC
Ascending node at	-118.7	
Nodal period:	94.31170	min
Longitude increment:	23.575255	deg
w/orbit Element set	817	
epoch: Fri Nov 29	03:16:57.278	1985 UTC

oscar-11

Sun Dec 8	00:47:31.935	1985 UTC:
Ascending node at	-42.2	
Nodal period:	98.55302	min
Longitude increment:	24.637942	deg
w/orbit Element set	100	
epoch: Wed Nov 27	15:07:27.391	1985 UTC

RS-5

Sun Dec 8	00:37:54.261	1985 UTC:
Ascending node at	124.3	
Nodal period:	119.55292	min
Longitude increment:	30.015187	deg
w/orbit Element set	280	
epoch: Wed Nov 27	03:36:28.87	1985 UTC

RS-7

Sun Dec 8	01:16:16.343	1985 UTC:
Ascending node at	109.0	
Nodal period:	119.19318	min
Longitude increment:	29.925211	deg
w/orbit Element set	225	
epoch: Sun Nov 24	15:26:58.457	1985 UTC

RS-8

Sun Dec 8	01:42:21.647	1985 UTC:
Ascending node at	111.2	
Nodal period:	119.76175	min
Longitude increment:	30.067413	deg
w/orbit Element set	350	
epoch: Wed Nov 27	04:13:34.59	1985 UTC

Wednesday December 11, 1985

oscar-9

Wed Dec 11	01:21:46.705	1985 UTC:
Ascending node at	-123.1	
Nodal period:	94.31120	min
Longitude increment:	23.575128	deg
w/orbit Element set	817	
epoch: Fri Nov 29	03:16:57.278	1985 UTC

oscar-11

Wed Dec 11	01:03:51.820	1985 UTC:
Ascending node at	-46.2	
Nodal period:	98.55295	min
Longitude increment:	24.637927	deg
w/orbit Element set	100	
epoch: Wed Nov 27	15:07:27.391	1985 UTC

RS-5

Wed Dec 11	00:21:48.548	1985 UTC:
Ascending node at 123.7		
Nodal period:	119.55290	min
Longitude increment:	30.015183	deg
w/orbit Element set	280	
epoch: Wed Nov 27	03:36:28.87	1985 UTC

RS-7

Wed Dec 11	00:47:13.619	1985 UTC:
Ascending node at	111.7	
Nodal period:	119.19318	min
Longitude increment:	29.925211	deg
w/orbit Element set	225	
epoch: Sun Nov 24	15:26:58.457	1985 UTC

RS-8

Wed Dec 11	01:33:47.7	1985 UTC:
Ascending node at 108.8		
Nodal period:	119.76173	min
Longitude increment:	30.067407	deg
w/orbit Element set	350	
epoch: Wed Nov 27	04:13:34.59	1985 UTC

AO-10 Apogees

Day	Date Time	Lat. Long.
Sunday 08	Dec85 04:15:09	UTC 24.2S 149.2W
Monday 09	Dec85 03:34:11	UTC 24.3S 139.8W
Tuesday 10	Dec85 02:53:14	UTC 24.3S 130.4W
Wednesday 11	Dec85 02:12:16	UTC 24.4S 121.0W
Thursday 12	Dec85 01:31:18	UTC 24.4S 111.6W
Friday 13	Dec85 00:50:21	UTC 24.5S 102.2W
Saturday 14	Dec85 00:09:22	UTC 24.5S 92.8W

Via Phil Karn, KA9Q, and Vern Riportella, WA2LQQ

KENWOOD

...pacesetter in amateur radio

TR-9130

TR-9130 2 meter all mode

The TR-9130 is a compact rig that gives you 25 watts of RF power on all modes!! You can select your tuning steps from 100-Hz, 1-kHz, 5-kHz or 10-kHz. With six memories, you can program your favorite frequencies! (FM 1-5 Simplex or ±600-kHz offset, memory 6 non-standard offset, all six for simplex, any mode!) Dual digital VFO's, and transmit frequency tuning enhance OSCAR operations.

Internal battery back-up (9 V Ni-Cd not Kenwood supplied) retains memories for approximately 24 hours, in case you operate mobile and base!

Other convenient features such as automatic band scan, squelch circuit for FM/SSB/CW, tone switch, repeater reverse switch, CW semi break-in; sidetone, high performance noise blanker HI (25) LOW (5) power switch (FM/CW) RF gain control, and RIT circuit further enhance this expressive package!

Optional accessories:

- KPS-7A AC power supply.
- PS-20 AC power supply (TR-9500 only).
- BO-9A system base with memory back-up supply.
- SP-120 external speaker.
- TK-1 AC adapter for memory back-up.
- SP-40 mobile speaker.
- SP-50 mobile speaker.
- SW-100 A/B power meters.
- MC-55 Mobile Mic w/time-out timer.

TR-9500

70 CM SSB/CW/FM transceiver

- Covers 430-440 MHz, in steps of 100-Hz, 1-kHz, 5-kHz, 25-kHz or 1-MHz.
- CW-FM Hi—10 W, Low—1 W. SSB 10 W.
- Automatic band/memory scan. Search of selected 10-kHz segments on SSB/CW.
- 6 memory channels.

TS-711A/TS-811A

Multi-function all-mode 2 m and 70 cm transceivers.

The TS-711A 2 m (142-149 MHz) and TS-811A 70 cm (430-450 MHz) all-mode transceivers are perfect base station units, designed to complement your present HF station. Both feature Kenwood's innovative D.C.S. circuitry. Built-in dual digital VFO's provide commercial-grade frequency stability through the use of a TCXO (Temperature Compensated Crystal Oscillator). The new fluorescent multi-function display shows frequency, RIT shift, VFO A/B, SPLIT, ALERT, repeater offset, digital code, call sign code, and memory channel. 40 multi-function memories store frequency, mode, repeater offset and tone. They have programmable scan, memory scan, and mode scan. The Auto-mode function automatically selects the correct mode for the frequency being used. When a mode key is depressed, an audible "beeper" announces mode identification in International Morse Code.

The TS-711A/TS-811A also feature all-mode squelch, noise blanker, speech processor (SSB, FM), IF shift, RF power control, alert, and a unique channel Quick-Step tuning that varies tuning characteristics from conventional VFO feel, to stepping action when CH.Q switch is depressed.

Combine all these features with built-in AC power supply and a hefty 25 watts RF output power and you have your ideal base station.

Optional accessories:

- CD-10 Call sign Display
- TU-5 CTCSS Tone Unit • VS-1 Voice Synthesizer • MC-60A Deluxe Desk Mic • MC-80 Desk Mic • MC-85 Desk Mic
- SP-430 External Speakers
- MB-430 Mobile Mount
- PG-2J DC Cable